OCTOBER 3, 1960
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Chemical Engineering

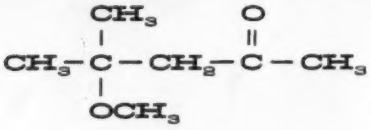
A McGRAW-HILL PUBLICATION

PACKAGING

There's also a just-right package for your solid and liquid products — CE Report, p. 85

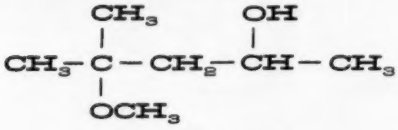
2 NEW HIGH BOILING SOLVENTS FROM SHELL

PENT-OXONE* SOLVENT



Keto-ether

PENT-OXOL* SOLVENT



Glycol-ether

for use in acrylic, vinyl, and nitrocellulose lacquers

PENT-OXONE is an excellent solvent for a wide variety of dissimilar resins. In *acrylics* it gives high performance at low cost. It promotes low viscosity, superior gloss, and excellent flowout. PENT-OXONE is a superior low-cost high boiler for solution-type *vinyls* because it makes possible high solids, desirable volatility characteristics, and high aromatic hydrocarbon tolerance. It has outstanding solvency for *nitrocellulose*. Because of its excellent blush resistance and dilution ratios comparable to low boilers, PENT-OXONE will be used in formulating metal and wood lacquers, and lacquer thinners.

PENT-OXOL's solvency and volatility help achieve a desirable balance between viscosity, flowout, gloss, and blush resistance. It promotes superior gloss and flow in *acrylic* formulations. In the *vinyl* coatings field, preliminary data indicating that PENT-OXOL peptizes vinyl chloride homopolymers suggest its use as an organosol dispersant. It gives outstanding blush resistance to *nitrocellulose* lacquers while eliminating the prolonged evaporation time commonly associated with blush-retarders. Its evaporation rate and solvency make PENT-OXOL particularly suitable for high-low type thinners.

PENT-OXONE	PHYSICAL PROPERTIES	PENT-OXOL
147.0-163.0°C.	ASTM BOILING RANGE	163.8-167.0°C.
141°F.	FLASH POINT	140°F.

PENT-OXONE and PENT-OXOL show promise as high boilers for epoxy coatings, thermosetting acrylic formulations, vinyl-acrylics, and other surface coating applications. They should find use as solvents in a wide range of uses not directly connected to the surface coating industry.

*Trademarks, Shell Chemical Company

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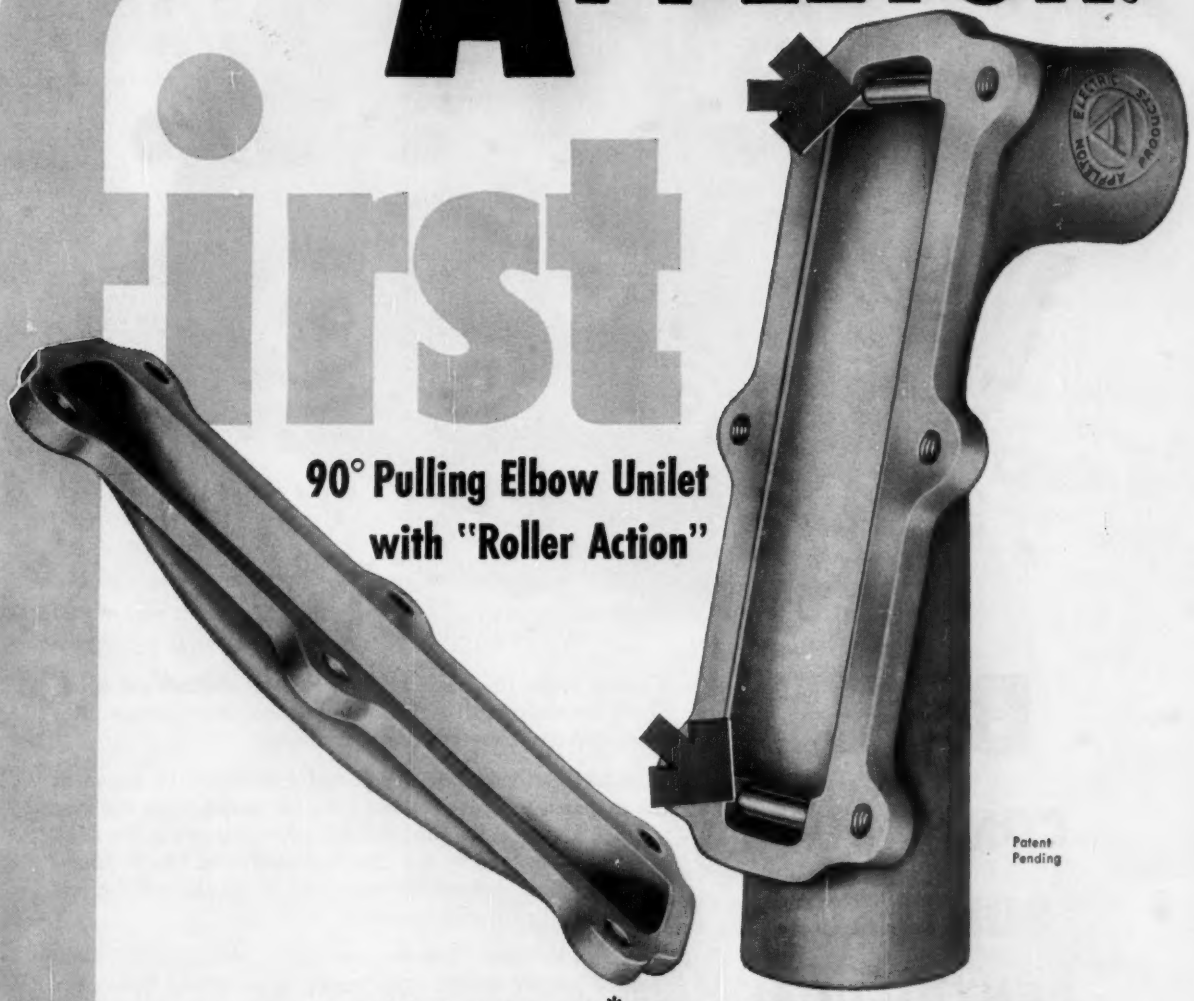
first

90° Pulling Elbow Unilet with "Roller Action"



Patent Pending

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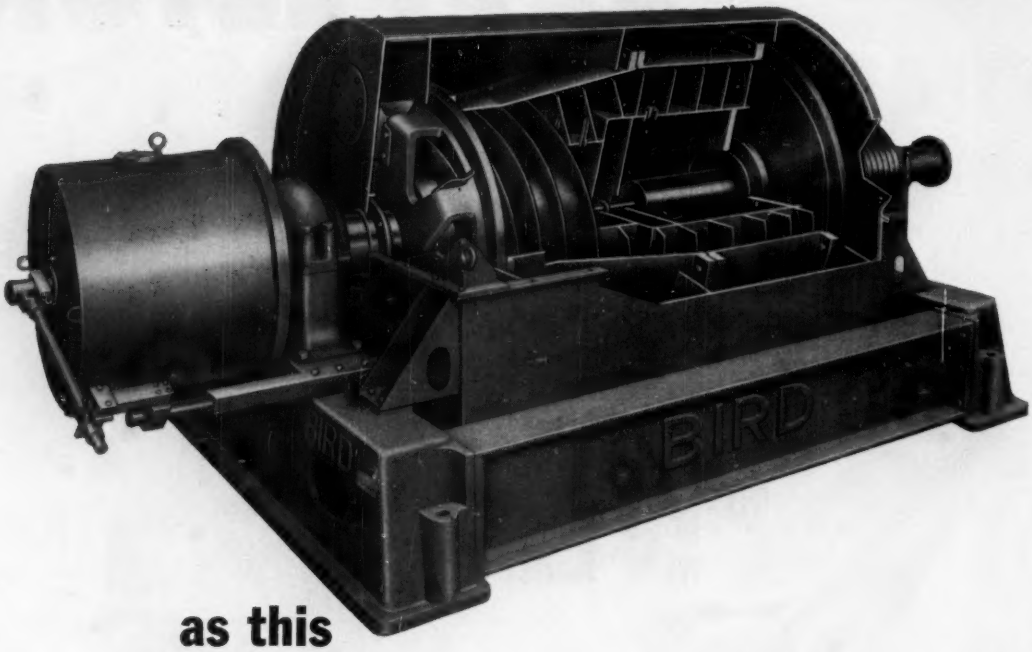
There are a dozen ways to separate solids from liquids but none so broadly useful, successful, dependable, economical



as this

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Chemical Engineering

October 3, 1960

CHEMICAL TECHNOLOGY FOR PROFIT-MINDED ENGINEERS

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Chemical Engineering (with Chemical & Metallurgical Engineering) is published biweekly by McGraw-Hill Publishing Company, Inc., James H. McGraw (1860-1948), Founder.

Publication Office: 99-129 North Broadway, Albany 1, N. Y.

Executive, Editorial, Circulation and Advertising Offices, 330 West 42nd St., New York 36, N. Y.

Officers of the Publications Division: Nelson L. Bond, President; Shelton Fisher, Wallace F. Traendly, Senior Vice Presidents; John R. Callaham, Vice President and Editorial Director; Joseph H. Allen, Vice President and Director of Advertising Sales; A. R. Venezian, Vice President and Circulation Coordinator. **Officers of the Corporation:** Donald C. McGraw, President; Joseph A. Gerardi, Hugh J. Kelly, Harry L. Waddell, Executive Vice Presidents; L. Keith Goodrich, Vice President and Treasurer; John J. Cooke, Secretary.

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Second class postage paid at Albany, N. Y. Printed in U.S.A.

Subscriptions: Send correspondence and change of address to Fulfillment Manager, Chemical Engineering, 330 West 42nd Street, New York 36, N. Y. Send notice promptly for change of address, giving old as well as new address. Enclose an address label from a recent issue of the magazine if possible. Allow one month for change to become effective.

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Chemical Engineering
OCTOBER 3, 1960

highlights of this issue

CHEMICAL SHOCK-TUBE RESEARCH

The shock tube offers chemical engineers a new way to explore gas-phase reactions at high temperatures and extremely short reaction times. This article (p. 107), written by an engineer actively engaged in shock-tube research, will help you decide how you might be able to use this technique.

FLASK-TANK SETUP FOR NEW INSECTICIDE

An interesting, unusual new product—a microorganism that is toxic to insects but not to plants and animals—is now being made on a tonnage basis via a fermentation process. This story (p. 42), from Western Editor Marty Robbins, tells how it's done.

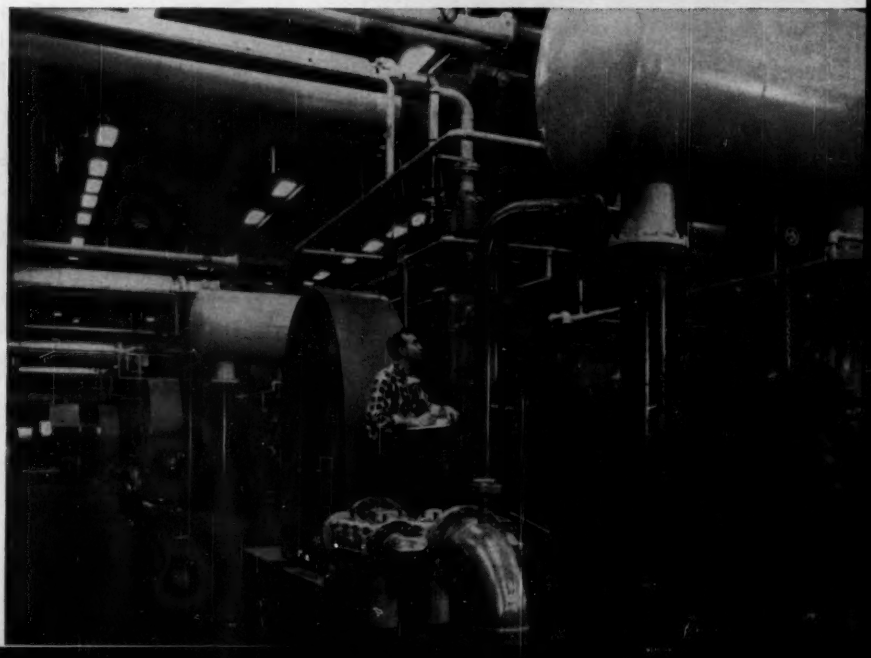
CONTAINERS FOR CHEMICALS

How shall we package our new product? This question should be considered early in any process or product development program—never as an afterthought. Thomas E. Dowling, Cyanamid chemical engineer turned packaging expert, provides a wealth of information (p. 85) on containers and filling machinery, with special emphasis on cost data.

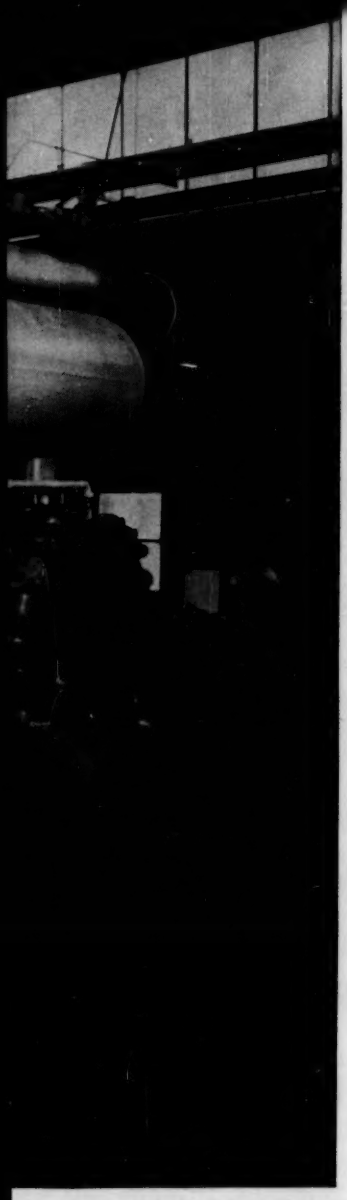
WHAT BASIS FOR COMPARING SALARIES?

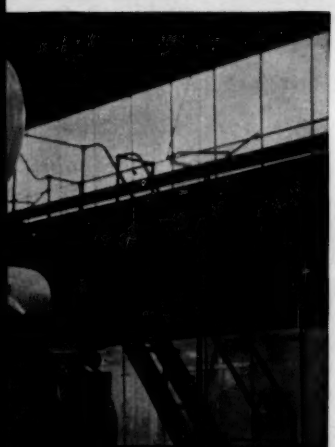
Should salary data be reported on the basis of age, experience, job definition or some other factor? A consistent basis would permit more meaningful comparisons among various sources of data. As shown in You & Your Job (p. 125), "calendar age" data correlate well with "years since initial degree."

Cooper-Bessemer compressor shown is one of two units for compression of synthesis gas.



View showing the four Cooper-Bessemer compressors. Unit in foreground is for "mixed gases" (air, nitrogen and methane).





Henry LaRue, *Ammonia Area Superintendent, Spencer Chemical Company, Vicksburg, Mississippi explains...*

How we compress four different gases with a team of four Cooper-Bessemer compressors

"Our entire ammonia plant depends on the uninterrupted flow of component gases, compressed by four Cooper-Bessemer GMW-8 Compressors," reports Mr. LaRue. "These four 2000 hp gas engine driven units have been the heart of our system 24-hours a day, day in and day out, since 1953.

"Two of the compressors, with five cylinders each, compress three different gases... air, nitrogen and methane. The other pair of compressors pump a synthesis gas mixture of hydrogen and nitrogen.

"Despite their 'round-the-clock operation for seven years, none of these Cooper-Bessemer compressors has had a major down-time for maintenance. They represent a sound investment."

Cooper-Bessemer engineers are at your service to help you plan compression and power facilities. Call the nearest office.

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Dow **C.P.I.** *file*

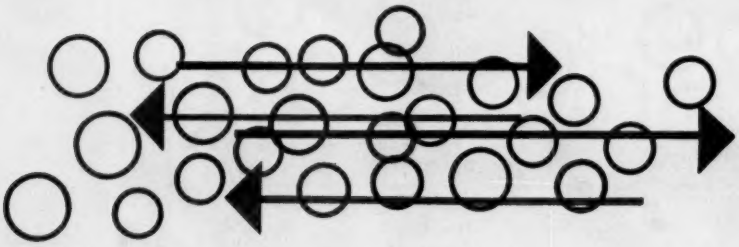
CHEMICAL ISOLATION

New techniques are allowing chemical separations and isolations formerly impossible. With this issue, Dow begins a new CPI File Series, "Chemical Isolation."

Practical, new applications of old processes are giving chemical processors separation and isolation methods with a high resolving power. Among these processes are ion exchange, chelation, flotation, and extraction.

In ion exchange, Dow has available a long list of ion exchange resins of both the cation and anion types. Today these improved resins and the advanced technology of the ion exchange process have been responsible for the broad acceptance of ion exchange as a chemical processing unit operation. Specific applications of Dowex® ion exchange resins will be presented in this series with new information being presented as it is developed.

Chelating agents also are adding a fineness to chemical processing that allows a very delicate control of metal ions. Again, while the chelating process is old, new chelating products and technology have extended the use of chelates throughout the chemical industry.



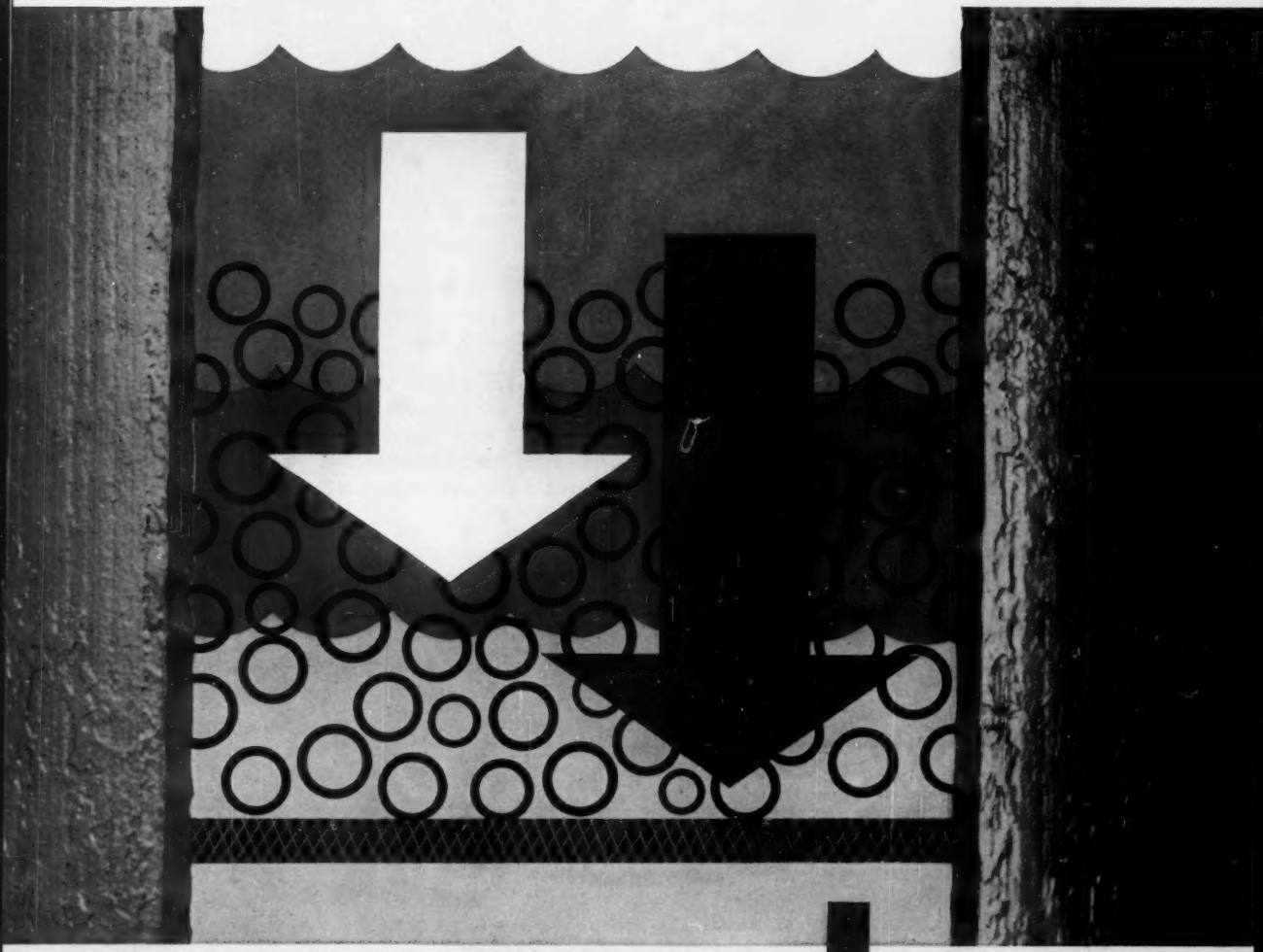
Future advertisements in this series will take up flotation, extraction, and other chemical isolation processes. Additional information on the application of the Dow chemicals in this series is readily available. A coupon is included for this purpose on the second page following.

DOW | **THE DOW CHEMICAL COMPANY** • Midland, Michigan

Dow C.P.I. file 4

CHEMICAL ISOLATION

ION EXCLUSION is a branch of ion exchange chemistry notable for the efficiency and simplicity of its action. Described below and on the next page is an ion exclusion process using Dowex ion exchange resins. This process shows a method of separating ionized materials from non-ionized or slightly ionized materials when both are present in a water solution. No chemical regenerant is needed. The separation is dependent upon the physical and chemical properties of the resin, and no net ion exchange takes place.



WHEN AN AQUEOUS SOLUTION of two or more solutes is passed through an ion exclusion column, a separation of the solutes occurs and they appear in separate fractions in the effluent. Briefly, this is what happens: When an aqueous solution of solutes (such as NaCl and glycerine) is run through an ion exclusion column of ion exchange resin, the *nonelectrolyte* tends to concentrate *inside* the resin particles while the *electrolyte* has a higher concentration in the interstitial liquid. Although this separation is dependent on many variables, the most important is the distribution constant K_d, shown in the equation at the right, where C_i is the concentration of the solute in the resin phase, and C_o is the concentration of the solute in the solution *outside* the particle. For example, with Dowex 50W, K_d for glycerine is 0.59 and for NaCl is 0.19. This differential in K_d's makes the separation of solutes possible, and can be used to determine the order in which a group of solutes will travel down an ion exclusion column. In the case of an aqueous solution of ionic and nonionic solutes, the ionic material appears in the effluent first.

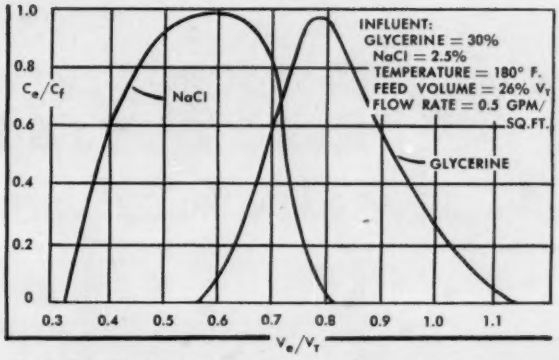
$$K_d = \frac{C_i}{C_o}$$

ION EXCLUSION

LOW-COST IONIC-NONIONIC SEPARATIONS WITH ION EXCLUSION PROCESS

Results obtained from operating a pilot plant, using the ion exclusion process for the separation of crude glycerine from its dissolved salts, proved to be predictable. Lack of necessity for chemical regeneration in this process is an important factor in the low cost of operation. Other typical separations achieved by the use of ion exclusion are: acids and salts from alcohols, glycols, and amino acids; the separation of strongly ionized from weakly ionized materials such as acetic acid and mineral acids; and mono-, di-, and trichloroacetic acid.

The glycerine obtained from the pilot plant, which was finished by ion exchange and evaporation, meets or exceeds U.S.P. specifications for glycerine. Although U.S.P. glycerine cannot be made economically by the ion exclusion process alone, further processing of the glycerine effluent from the ion exclusion column by ion exchange to remove the remaining trace of ionic material and concentration by evaporation will produce U.S.P. glycerine of a very high quality. A cost analysis indicates that U.S.P. glycerine could be produced by ion exclusion followed by ion exchange and evaporation for one cent per pound.



PILOT PLANT ELUTION CURVE. Graph shows pilot plant elution curve when feeding approximately 30% crude glycerine and 2.5% salt. Feed was made by diluting, with softened water, 82% crude glycerine. Since these eluant curves remain constant under proper operating conditions, a time cycle can be developed from the curve for automatic operation.

CHELATION

CONTROL UNDESIRABLE SIDE EFFECTS OF TRACE METAL IONS WITH CHELATING AGENTS

Chelating agents can control many of the undesirable side effects which metal ions cause in processing operations. So effective are the new chelating agents that metal ions, even though still in solution, are virtually eliminated from reactions and are difficult to detect even by chemical means. If a number of different metal ions are present in a system, a chelating agent will complex with the metals in a predictable order of decreasing stabilities. For example, if copper, zinc, and calcium are present in a system, all the copper will be chelated first, then the zinc, then the calcium. Nearly all polyvalent metal ions react to form stable chelates.

VERSENE PRODUCTS SOLVE MANY METAL ION PROBLEMS

- **Formation of unwanted insoluble precipitates**
- **Deposition of sludges and scales**
- **Catalytic promotion of unwanted reactions**
- **Reaction with complexing agents to give unwanted colors**
- **Oxidative breakdown and spoilage of organic material (soaps, fats, oils, flavors, pharmaceuticals, etc.)**
- **Actions causing instability in emulsion systems**
- **Interference with processing steps (bleaching, dyeing, plating, finishing, etc.)**

VERSENE® 100 and VERSENEX® 80 are the most widely applicable Dow chelating agents. Both are broad-spectrum chelating agents forming complexes with the same metal ions. Generally, the stabilities of metal ion chelates of Versenex 80 are greater than those of Versene 100. Versenex 80 is, in general, indicated where unusual stability requirements are necessary.

Specialty Chelating Agents are available from Dow for specific problems such as iron control at basic pH, and heavy metal control in strong concentrations of the hardness ions.

Wherever metal ions are found, Dow chelating agents can probably help to control them. Write, stating your problems, to Dow, or mail coupon for descriptive literature.

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The Dow Chemical Company, Midland, Michigan
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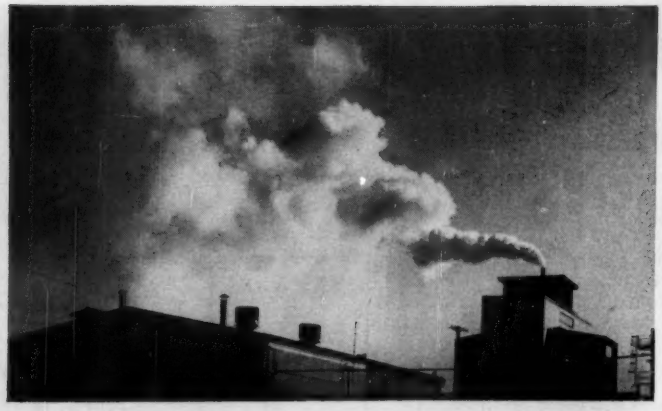
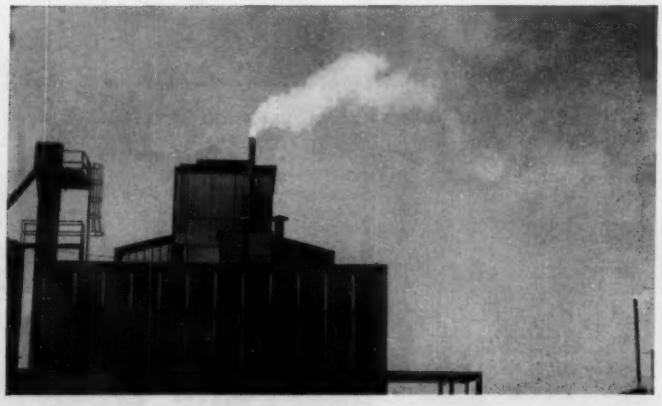


Before scrubber was installed —visible cloud is composed largely of water with about 0.5% sulfur trioxide

THE CHEMICO VENTURI SCRUBBER MAKES THE BIG DIFFERENCE



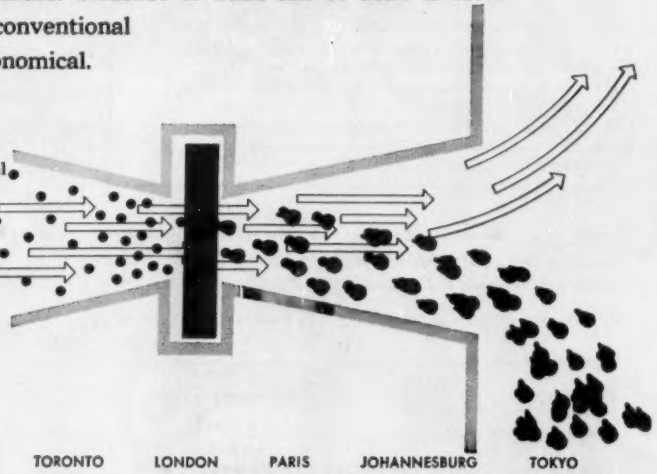
After scrubber was installed— water vapor has diminished considerably, sulfur trioxide content is practically nothing

With sulfur trioxide fumes being vented to the air in a thick vapor fog, Ansul Chemical faced an air pollution problem common to many chemical producers. They were willing and anxious to comply with community requests for pollution control, but they were unable to find a scrubber which could rid the stack of both the water vapor and the SO_3 as well.

While virtually any scrubbing device was capable of removing the water vapor, only the Venturi scrubber was effective in removing the acid fumes. By removing all but the last traces of SO_3 the Venturi scrubber gave further evidence of what can be done to solve really tough gas cleaning problems where conventional cleaning devices prove ineffective or uneconomical.

FULL DETAILS AVAILABLE

For your copy of a brochure giving complete data on Chemico Venturi gas scrubbers, or for technical assistance on a specific problem, write to Chemico at the address below.



CHEMICO

CHEMICAL CONSTRUCTION CORPORATION
Gas Scrubber Division
525 West 43rd Street, New York 36, New York

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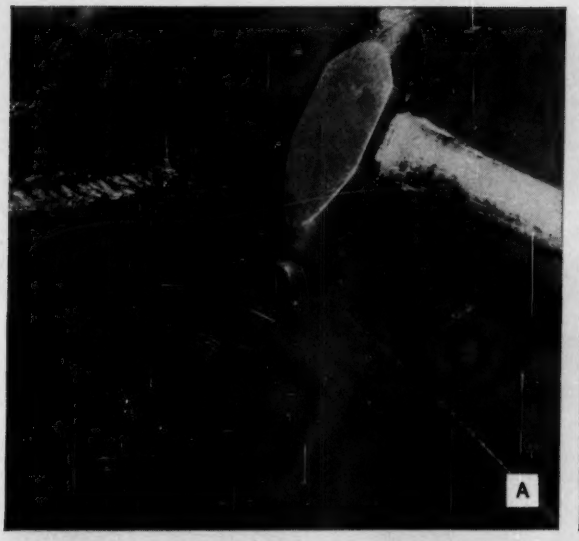

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D **Inside information**—The Magnaflux test... another way to inspect a welded seam... is frequently used to check critical pressure vessel welds at Downingtown.

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CONTAINERS AND PRESSURE VESSELS FOR GASES, LIQUIDS AND SOLIDS

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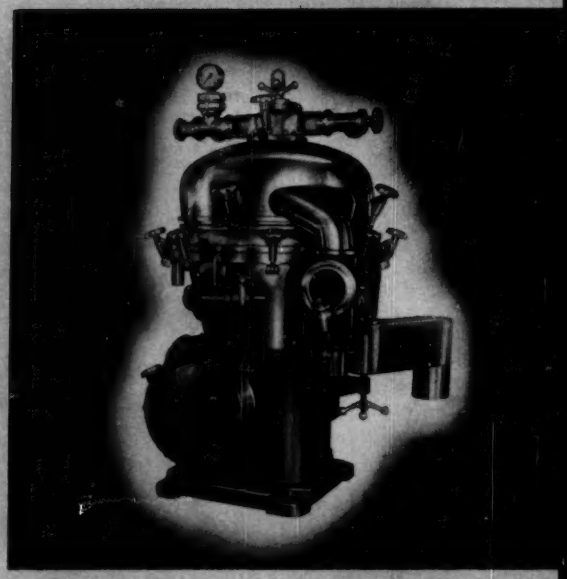
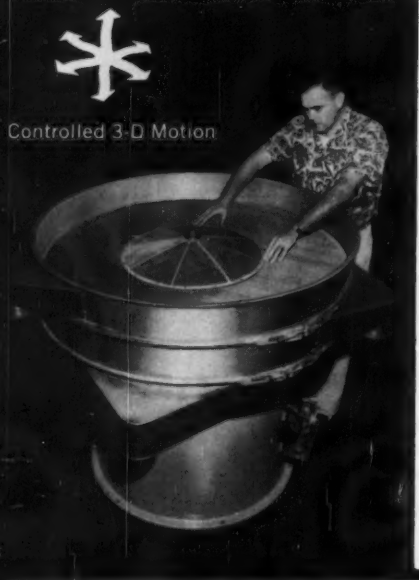


...economically!



Getting all shook up on one horsepower!

It speaks well for the design and operating efficiency of the De Laval Syncro-Matic that its high-capacity 3-dimensional screening action is all accomplished with a *one* horsepower motor. The energy you pay for is concentrated on your product rather than being dissipated by attacking your floor beams. Tune the controls for gentle sifting or for turbulent, high-throughput classification and you can count on quiet, practically vibration-free performance.

Unlike ordinary screens based on eccentric weights, the action of the De Laval Syncro-Matic is positive and controllable—and unaffected by variations in screen loadings. Use of the three calibrated motion controls lets you achieve optimum screening action. Capacity improvements in the range of 50 to 300% over conventional equipment have been reported.

Mounted screens (single, double or triple) are drum-tight—easily and quickly replaceable. Choose between plain or stainless steel construction. Your product – wet or dry, fine or coarse, crystal-hard or delicately soft – will be more efficiently classified, more rapidly processed—or both.

For Further Information Write To Dept.C-10

DE LAVAL

THE DE LAVAL SEPARATOR COMPANY
Poughkeepsie, New York
5724 N. Pulaski, Chicago 46, Illinois

DE LAVAL PACIFIC COMPANY, Dept.
201 E. Millbrae Avenue, Millbrae, Calif.

CENTRIFUGES
PLATE HEAT EXCHANGERS
VIBRATING SCREENS
COMPLETE PROCESSES

After the "Clarifier" and the "Nozzle-Bowl" ...what?...This!

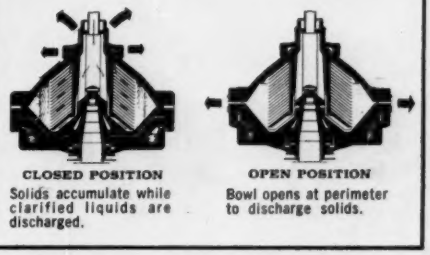
Problem A: An immiscible liquid mixture is to be centrifugally separated. An unwanted heavy sediment is also present.

Problem B: A solids suspension is to be continuously separated from a liquid (or liquid mixture), concentrated and reclaimed.

Complication: The solids are so plentiful they fill a "clarifier" bowl too quickly. Or the feed rate is too low to warrant a continuous-discharge nozzle-bowl centrifuge. Or the solids are too large for nozzle discharge. Or you want to wash the solids before discharge. Or...

Solution: Such complications dissolve into routine operating procedure when one of De Laval's new PX self-opening separators is used. While the liquid mixture is being efficiently separated and discharged, the solids accumulate in the ample bowl wall space. At a predetermined solids build-up, the bowl is opened at the perimeter, and pffft!... out go the solids to a discharge cover. The De Laval "PX" never misses an RPM!

Applications possibilities are legion in the processing of foods, fats, oils and chemicals...especially for De Laval's unusually compact, more economically operated models. Be the first in your group with the facts! Write for the "De Laval PX Self-Opening Separator" leaflet!



CLOSED POSITION
Solids accumulate while clarified liquids are discharged.

OPEN POSITION
Bowl opens at perimeter to discharge solids.

AN INCH, AN OUNCE, AN ERG...

Small differences add up to significant considerations when choosing equipment. The economy of power in our Synchro-Matic screen separators has its **real** meaning in operating performance. Inches add to many cubic feet or yards saved with our remarkably compact Plate Heat Exchangers. Special disc design in our Centrifuges makes a larger capacity possible for a given frame size. Such not-so-small differences add up to many years of operating payoff!

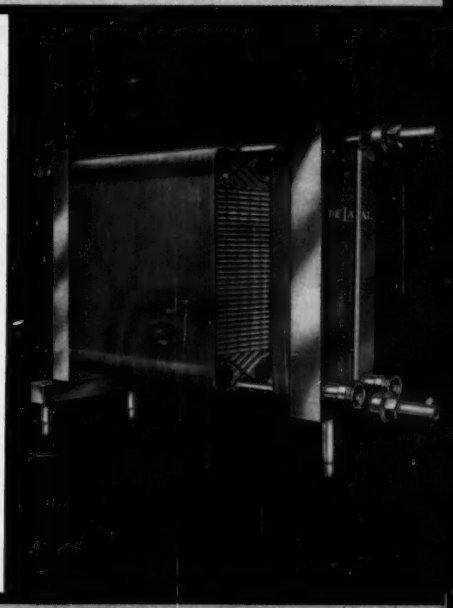
Fred Wheelwright, Industrial Manager

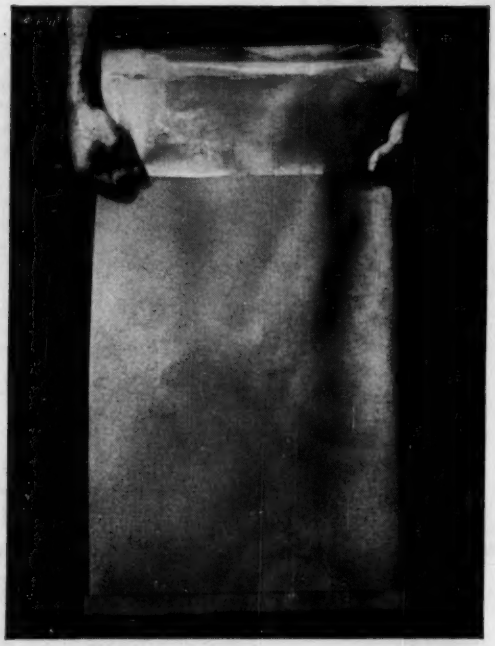
Laminar flow licked at Reynolds no. 180!

Memory being what it is, process engineers often forget that a 2100 Reynolds number is the borderline for turbulent flow *only* for flow in smooth tubes. In our De Laval Plate Heat Exchangers, the plate corrugations completely frustrate laminar flow and many operate with high transfer efficiency at Reynolds numbers in the range of 180.

Then there's the fact that heat transfer coefficients are normally 600-750 and often over 900 Btu/hr-ft²-°F. And also that for equal heat transfer coefficients, De Laval Plate Heat Exchangers require a lower pressure drop than shell-and-tubes.

With operating efficiencies that shell-and-tubes can't match – with multi-compartmentation easily arranged – with remarkable compactness – and with easily added capacity at any time – De Laval's stainless steel Plate Heat Exchangers are gaining steadily on the cheaper (but more costly to install and operate) shell-and-tubes. Join the "modern design" group. Send for booklet!





Now you can ship caustic soda in 50- or 100-lb. bags . . .

Bemis Caustic Soda Bags

Bemis Caustic Soda Bags, approved for both rail and truck shipment in 50- and 100-lb. sizes, dramatically change the packaging picture for caustic soda. These rugged bags give you economies you can't afford to pass up . . . plus other important benefits. Expensive steel drums are made obsolete. Call your Bemis packaging specialist today for complete details. Or, write, wire or phone us.

EIGHT BIG BENEFITS ■ **Lower Cost**—Considerably below what you now pay for steel drums. ■ **Storage Economy**—A ton of caustic soda packed in Bemis Bags takes 50 per cent less storage or shipping space than a ton packed in drums. ■ **Empty Container Storage Economy**—400 empty Bemis Bags take a fraction of the space occupied by 200 drums. ■ **Lower Freight Costs**—The bags to carry one ton of caustic soda weigh 100 pounds less than the drums needed for the same job . . . a 75 per cent saving in package weight, a 5 per cent over-all tare weight saving. ■ **Labor Savings**—One truck can be loaded in 20 minutes with palletized bags; same truck takes 1½ hours to load with drums, using three men in each case. ■ **Better Handling**—Bemis Caustic Soda Bags are easy and safe to handle and stack. Nonslip surface permits safe palletizing. ■ **Easier, Cheaper Disposal**—Just burn or bury the used bags; you know the problems of disposing of drums. ■ **Strength**—Bemis Laminated-Textile Bags—Caustic Soda Bags are one type—have been called the toughest shipping sacks made. Actual shipments by one manufacturer have proved they carry caustic soda as safely as drums.

GENERAL OFFICES—408-R Pine Street, St. Louis 2 • CHestnut 1-0900
Sales Offices in Principal Cities

Where flexible packaging ideas are born

6 FOR THE 60'S

Six Worthington centrifugal pump lines selected by Worthington Technical Representatives as giving the most value to their customers.

WORTHINGTON

6 for the 60's Pump Information Guide

The ideal product combination of economical design and efficient performance requires programs in many areas—Research, Engineering, Manufacturing—are only a few. Knowledge gained by Worthington in these areas is used to improve pump design and is made available to pump users as well.

Worthington projects making this knowledge available have taken many forms. For example:

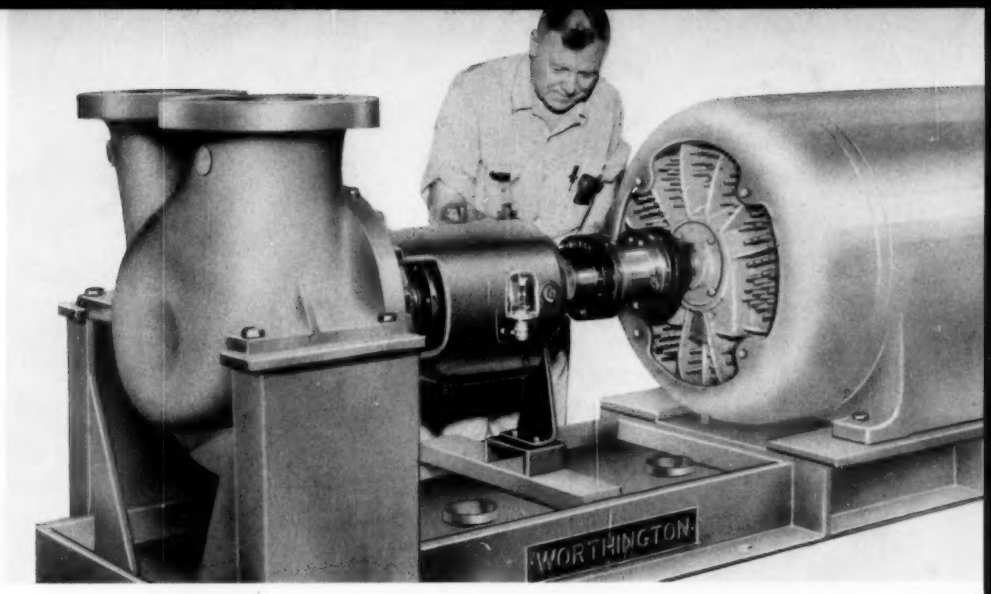
Technical Pump Seminars—currently being conducted with customers throughout the country.

The Centrifugal Pump Clinic—presented in the form of questions and answers in the interests of better pump operation.

Reprints of Technical Articles—detailed discussions of pump application and design topics. Two typical releases are "An experimental investigation of radial thrust in centrifugal pumps" (RP-1087) and "Cavitation and NPSH" (RP-1094). These two papers represent extensive research at Worthington's Harrison, New Jersey Research Laboratory.

Your Worthington Technical Representative will be glad to discuss your pumping problems and provide information on the above programs—call him at your local Worthington District office.

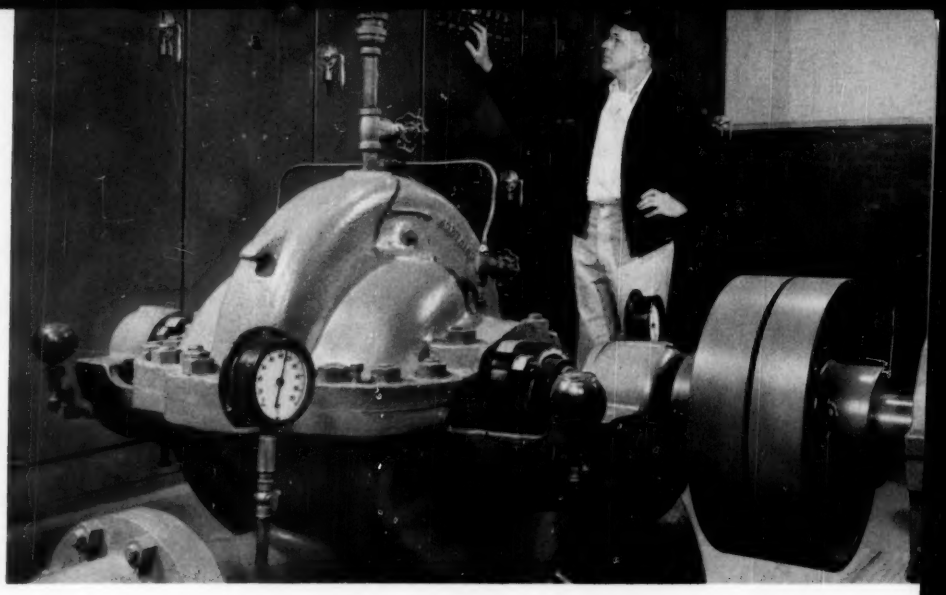
HN



MOST ECONOMICAL FOR PROCESS JOBS—REQUIRE LESS NPSH

Worthington HN pumps offer remarkably low NPSH requirements. Construction features are outstanding, too. For example, the positive ring oil lubrication system and bearing housing protected against contamination assure long trouble-free service. And the large diameter cantilever shaft assures negligible deflection, thus prolonging wearing ring, seal or packing and sleeve life. Built for flexibility and interchangeability, HN pumps handle temperatures to 850F and pressures to 600 psi.

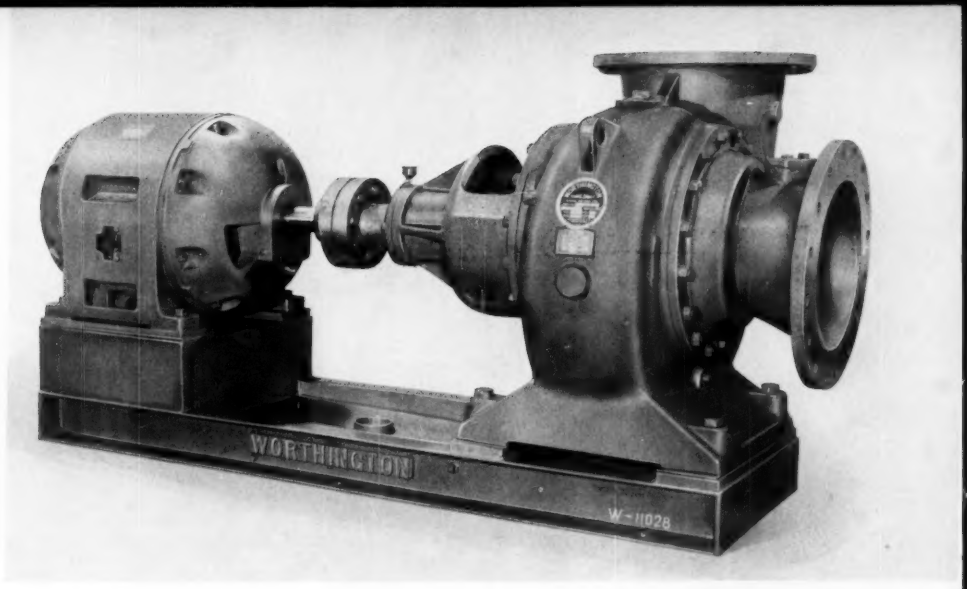
LN



"DOUBLE VOLUTE" DESIGN IS RADIALLY BALANCED AT ANY LOAD

These general purpose pumps use a casing design that gives hydraulic balance at any capacity. This design, called "Double Volute," makes pump operation possible from design point back to shut-off without adverse effects of hydraulic radial reaction. "Double Volute" design reduces wear and makes an LN pump one of the most reliable you can buy. And just as important, the LN design includes many other up-to-date features for economical installation and operation.

MC



HIGH CAPACITY AT LOW HEADS—WITHOUT CLOGGING

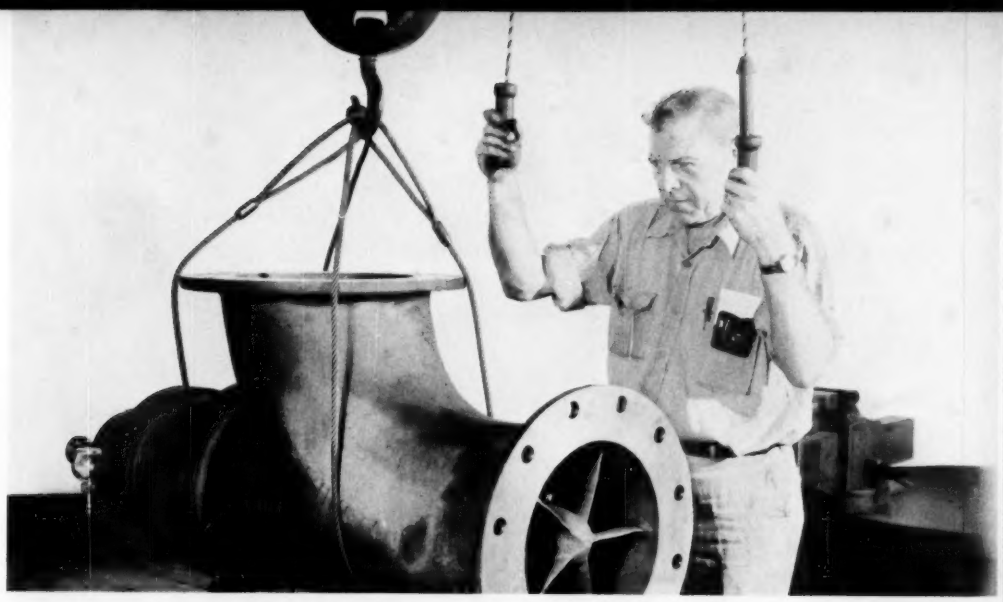
Type MC is the Worthington Mixflo pump—proven for irrigation, drainage, waste disposal, condenser circulating and low-head water supply. Non-clogging sewage type closed impellers pass large solids. There are variations in construction to suit any installation: bronze or chrome steel wearing rings; bronze or chrome steel shaft sleeve; vertical bottom suction models, discharge in any direction too. Sizes 10″ to 84″.

UN

A RUGGED, HEAVY-DUTY PUMP AT A COMPETITIVE PRICE

Any reputable manufacturer can build a pump that will outlast anything on the market. The trick is to do it at a competitive price, with proven design features. This dual ideal has been accomplished with Worthington's UNB and UNQ pumps through a planned program of standardized parts and simplified manufacturing techniques. Typical of the outstanding design features is the elastic seal ring that prolongs casing life by eliminating interstage leakage.

KB



AN ELBOW PUMP WITH APPLICATION AND INSTALLATION FLEXIBILITY

Worthington's KB elbow pumps have been designed to provide an economical combination of operating efficiency and NPSH requirements. The construction lends itself to installation in place of an elbow in a circulating system. Designed with top suction to reduce installation cost. KB elbow pumps are supplied in Type 300 stainless steels and Worthite—Worthington's super stainless.

SE-
SC

STANDARDIZATION TO CUT INVENTORY AND MAINTENANCE

This Worthington Standard End Suction Centrifugal line takes care of about 70% of all centrifugal pump requirements, as proven by sales records showing basic types of pumps purchased. Ratings range up to 2700 GPM and 230 ft. head. In each of 120 pump ratings, there's a variety of materials of construction, types of liquid ends, shaft sealing methods and drives. There are literally 70,480 combinations to choose from—but the extreme standardization can cut warehousing and inventory costs as much as 50% and reduce maintenance.

SIX CENTRIFUGAL PUMPS VOTED "BEST VALUE" FOR THE 60's

"Every salesman has his favorite product." And so do Worthington Technical Representatives. By vote they picked the six centrifugal pumps that were their "favorites"—preferred because they felt these Worthington pumps give you the most value for your pump dollar.

Remember, this value rating has been awarded by Worthington Technical Representatives on the basis of their observations of your operating needs. See the booklet below for a summary of the features that make each of these six pumps your best buy.

P.S. In an election like this some had to lose. Actually, picking the winners was tough . . . the Worthington pump line covers virtually every pumping job well. Tell us your problem . . . we'll gladly give you a recommendation based on an unbiased complete line selection.

WORTHINGTON

"6 for the 60's" Pump Information Aids

WORTHINGTON CORPORATION
Section 21-5
Harrison, New Jersey

Please send me application and performance data on the lines checked below:

HN_____ MC_____ KB_____

LN_____ UN_____ SESC_____

NAME_____

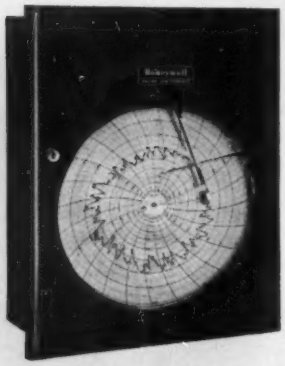
COMPANY_____

STREET_____

CITY_____ STATE_____

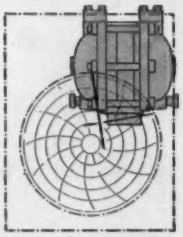
Honeywell Bellows Flow Meter

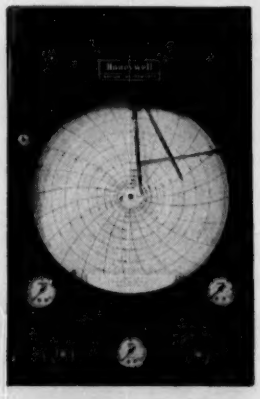
HERE ARE FOUR OF MANY WAYS YOU CAN USE THE BELLOWS FLOW METER



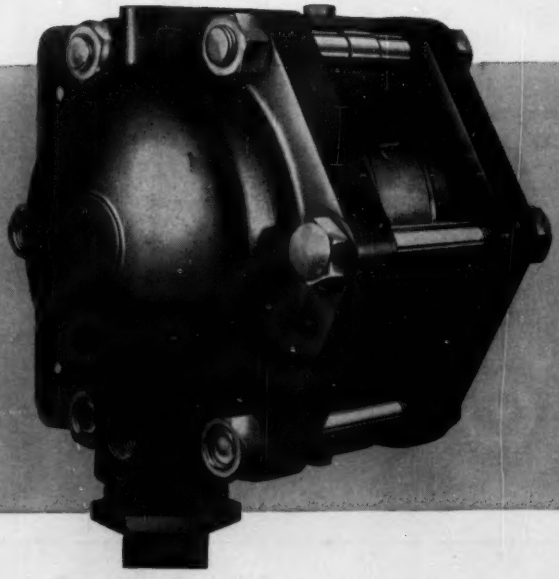
For direct measurement and control

the meter is integrally mounted on indicators, indicating controllers, recorders, or recording controllers.





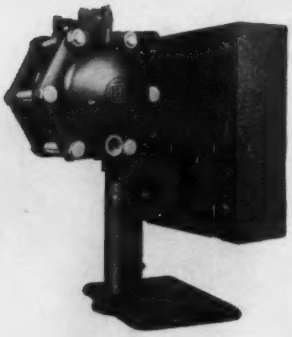
With an indicator or recorder—Indicators can be supplied with or without pneumatic transmission. Recorders can be one, two or three-pen instruments, with the second and third pens actuated by thermometer and/or pressure elements.



With indicating or recording controllers—All indicators and recorders can be supplied with any pneumatic control form from on-off to three-mode. Indicating controllers are also available with pneumatic transmission.

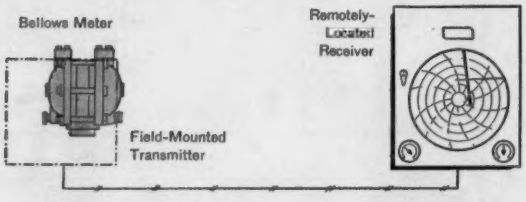
With a "blind" transmitter—the non-indicating differential pressure transmitter is used when indication is not required at the process and the variable is to be transmitted to remotely located instruments.

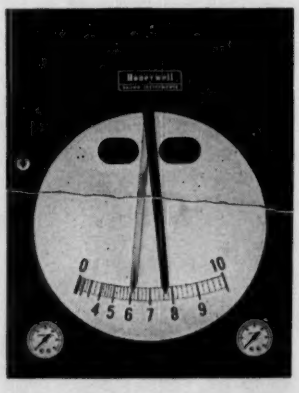
With an indicating transmitter—Scale is graduated in accordance with the flow or liquid level span of the transmitter. These transmitters are available with pneumatic control to remotely operate final control elements.



For remote measurement and control

Field-mounted transmitters, either "blind" or indicating, can be used with remotely located indicators, recorders, and controllers.





and with Tel-O-Set miniature instruments and a variety of options!

has applications unlimited

Unequaled for accuracy, stability, versatility in flow and liquid level metering

Here's the most advanced meter body available today, with advantages never before found in flow and liquid level meters. Combine the new Honeywell Bellows Flow Meter with the instruments shown on the facing page for truly superior service in metering steam, water, gas, oil and other fluids.

Some of its outstanding features:

Sensitive and accurate—Sensitive to within 0.05% of full scale . . . calibrated accuracy ± 0.5% of full scale.

Leakproof—Between liquid fill and process fluid.

Automatically stabilized—Changes in meter body temperature or static pressure have no effect on output shaft position. Meter operates efficiently in ambient temperatures of minus 40°F to plus 250°F.

Unmatched convenience features—Including fast range changing in the field . . . connections for both horizontal and vertical piping . . . quick calibration and adjustment . . . easy cleaning and servicing.

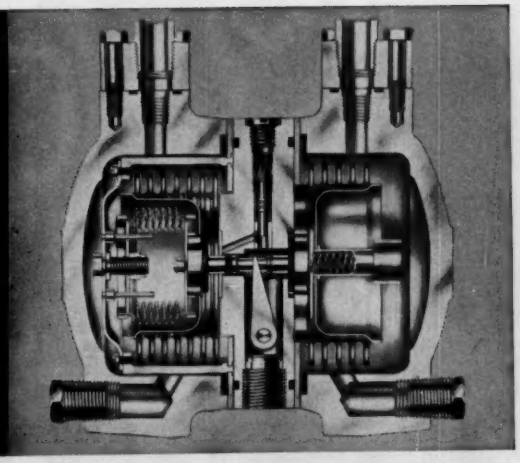
High corrosion resistance—Seamless, stainless steel formed bellows give long, trouble-free service with virtually all process fluids.

Fast, effective damping adjustment—New type pulsation check with rectangular orifice permits essentially linear damping adjustment . . . and adjustment from outside the meter body during operation.

Models are available in many ranges, for both flow and liquid level measurement and control. Get details on *all* the features of the new Honeywell Bellows Flow Meter by calling your nearby Honeywell field engineer today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.

REFERENCE DATA: Catalog C22-1



Transfer of liquid between opposing high and low-pressure bellows converts differential pressure measurement into motion. A torque tube assembly carries the motion outside the meter body to an instrument. Therefore, changes in differential pressure change the instrument reading.

Honeywell

First in Control

SINCE 1885

75th YEAR — PIONEERING THE FUTURE

NOW...

DeZurik Valves with VITON-COVERED PLUGS for LONG LIFE ON CORROSIVE LIQUIDS, SLURRIES, GASES!

Successful applications of DeZurik Valves with VITON covered plugs include Sodium Sulphide, Polyester Resin, Naphtha, Hot Tallow, Fish Oil, Maleic Acid, Phthalic Acid, Sulfurous Acid, Fuel Oil, Tar, Raw Coke Oven Gas, Sodium Hypochlorite, Coal Tar, Phosphoric Acid, Hexane, Tetraethyl Lead, Sulphuric Acid, Epoxy Resin, Chlorine, Ferrous Sulfate, Styrene, Gasoline, Nickel Carbonyl Gas, Hydrofluoric Acid, Formaldehyde, Steam, Perchlorothylene, Trisodium Phosphate.

DeZurik Valves are available in Semi-Steel, Bronze, Acid Resisting Bronze, Ni-Resist, Aluminum, Carbon Steel, Stainless Steel, Alloy 20, Nickel, Monel, Hastelloy B, Hastelloy C, and other metals.

This DeZurik Eccentric Valve, with Viton-covered plug, will CLOSE TIGHT and LAST LONGER on high temperature corrosives.

The physical properties of VITON are particularly desirable when combined with DeZurik Eccentric Valves. Its *resiliency* guarantees tight shut off, even on slurries! Its *temperature resistance* greatly extends the range of installations on which DeZurik Valves can be advantageously employed. And its *resistance to chemical attack* is shown in the partial list on the left.

These properties make VITON one of the fastest-growing members of the family of DeZurik plug-covering materials.

DeZURIK CORPORATION
SARTELL, MINNESOTA

VITON is a registered trademark of DuPont

Embossing press converted to electric heat.

Curved to match circumference of round pipe.

Mounted on side of dip tank.

Two heater groups, separately controlled for zoned heat.

EDWIN L. WIEGAND COMPANY

7500 Thomas Boulevard • Pittsburgh 8, Pa.
CHurchill 2-6400

CHROMALOX

ELECTRIC STRIP HEATERS

QUICK, LOW-COST SOLUTION TO PRODUCTION HEATING PROBLEMS

For heating tanks, kettles, pipes, platens, dies, ovens . . . just about anything. Chromalox Electric Strip Heaters provide uniform heat to exact temperatures.

Heaters available in shapes, sizes and wattages to fit hundreds of industrial heating needs . . . including yours. Installation is quick and easy . . . using standard bolts or clamps. Heaters give long service with little or no maintenance. Temperatures are maintained by either manual or automatic controls.

Write for Bulletin PA100. Or, for fast action and on-the-job assistance with your heating problems, call your Chromalox Sales Engineering Representative listed below. 01884

Call Your Chromalox Man for Heating Answers

ALBANY N.Y.
Hobart 3-0626

ATLANTA GA.
Trinity 5-7244

BALA-CYNWYD PA.
Mohawk 4-6113
Greenwood 3-4477

BALTIMORE MD.
Hopkins 7-3280

BLOOMFIELD N.J.
Edison 8-6900
New York: Worth 4-2990

BOSTON, MASS.
Cedar 5-8040

BUFFALO, N.Y.
TT-6-4000

CHARLOTTE, N.C.
Edison 4-4244
Franklin 5-1044

CHATTANOOGA, TENN.
Amherst 5-3862

CHICAGO, ILL.
Harrison 7-5464

CINCINNATI, OHIO
Trinity 1-0605

CLEARWATER, FLA.
Phone 3-7706

CLEVELAND, OHIO
Prospect 1-7112

COLUMBUS, OHIO
Amherst 7-8260

DALLAS, TEX.
Riverside 8-9004

DAVENPORT, IOWA
Phone: 6-5233

DENVER, COLO.
Glendale 5-3651
Genesee 3-0821

DES MOINES, IOWA
Cherry 3-1203

DETROIT, MICH.
(See Southfield, Mich.)

HOUSTON, TEX.
Capitol 5-0356

INDIANAPOLIS, IND.
Melrose 5-5313

KANSAS CITY, MO.
Victor 2-3306

LOS ANGELES, CAL.
Ludlow 9-6321

MIDDLETOWN CONN.
Diamond 6-9606

MILWAUKEE, WIS.
Broadway 1-3021

MINNEAPOLIS, MINN.
Federal 6-6631

NASHVILLE, TENN.
Cypress 2-7016

NEW YORK CITY, N.Y.
(See Bloomfield, N.J.)

OMAHA, NEB.
341-7600

PHILADELPHIA, PA.
(See Bala-Cynwyd, Pa.)

PITTSBURGH, PA.
Emerson 1-2900

PORTLAND, ORE.
Capitol 3-4197

RICHMOND, VA.
Atlantic 8-8758

ROCHESTER, N.Y.
Hamilton 6-2070

ST. LOUIS, MO.
Chestnut 1-2433

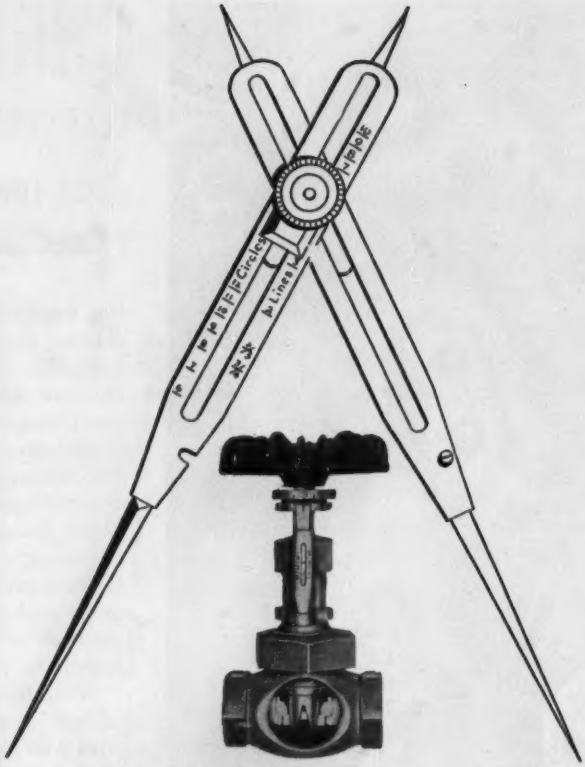
SAN FRANCISCO, CALIF.
Underhill 1-3000

SEATTLE, WASH.
Main 4-7297

SOUTHFIELD, MICH.
Kenwood 8-2100
Elgin 7-0677

SYRACUSE, N.Y.
Granite 4-3933

WICHITA, KAN.
Amherst 2-5647



PROPORTIONER

controls flow to save for you

The V-port disc in all Hancock "Flocontrol" Valves insures proportional flow throughout the entire lift of the stem. They are valves that help you achieve uniform product quality through closer control, save steam and fuel on process work, and cut maintenance costs.

"3 in 1" valve design combines variable orifice with shut-off and micrometer dial and pointer. The valve opening can be set within 1/10 turn of the handwheel —you can duplicate all settings easily, instantly. No shut-off valve required—flow is in a straight line, with separate shut-off seating surface located away from the V-ports.

Hancock "Flocontrol" Valves are available in Bronze and Steel to meet the most demanding services. Ask your industrial supply distributor for details.

Hancock "Flocontrol" valves assure positive pinpoint control—eliminate all guesswork.

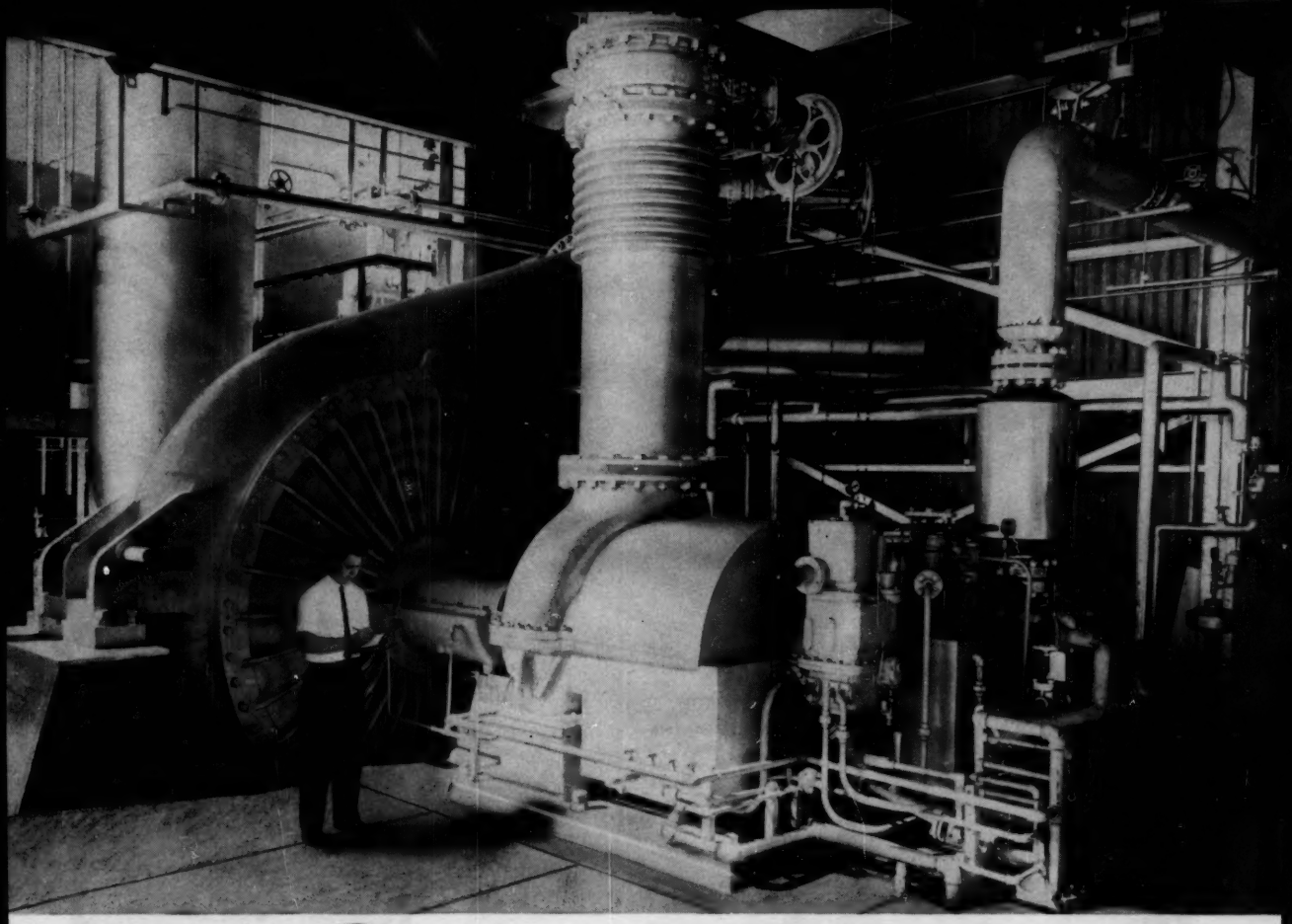
MAXWELL MM&M MANNING & MOORE INC. TRADE MARK

HANCOCK "FLOCONTROL" VALVES

A product of

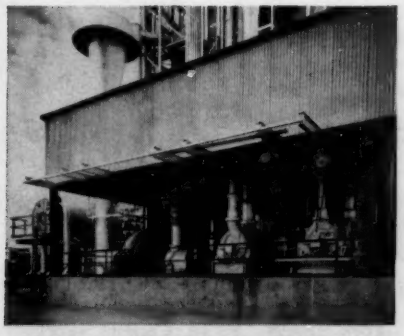
MANNING, MAXWELL & MOORE, INC.

Valve Division • Stratford, Connecticut
In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario



BIG SINGLE-STAGE ELLIOTT COMPRESSOR

furnishes combustion and lift air for TCC unit



In the compressor area are two Elliott multistage turbine-driven compressors, in addition to the large single-stage unit shown above.

The huge single-stage Elliott compressor shown above has inlet capacity of 74,750 icfm. It serves as a combination combustion air and lift-air compressor for a Thermofor catalytic cracking unit in a southern petroleum refinery. Inlet temperature is 100°F; inlet pressure, 14.3 pisa; discharge pressure, 19.5 pisa. The compressor is driven by a 2200-hp, 3000-rpm Elliott turbine.

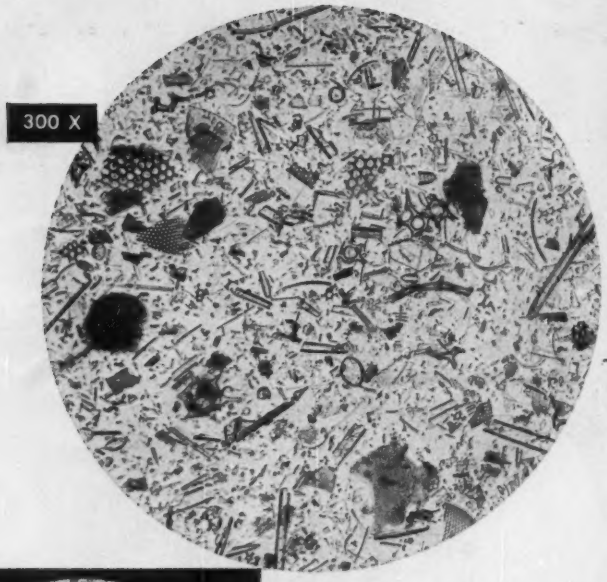
Elliott makes a complete line of centrifugal compressor units, consisting of single-stage, multistage and axial flow machines, with integrated Elliott motor or turbine drives. There are 48 frame sizes, permitting accurate matching of compressor to application requirements over the entire range of capacities, from 500 cfm to 600,000 cfm.

For full information, consult the nearest Elliott office, or write Compressor Department, Elliott Company, Jeannette, Penna.

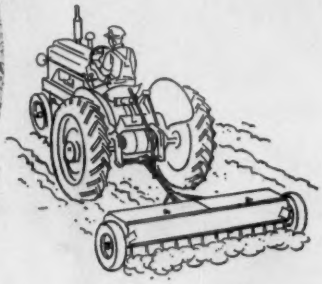
ELLIOTT THE MOST COMPLETE LINE OF **INTEGRATED COMPRESSOR & DRIVER UNITS** 500 cfm to 600,000 cfm

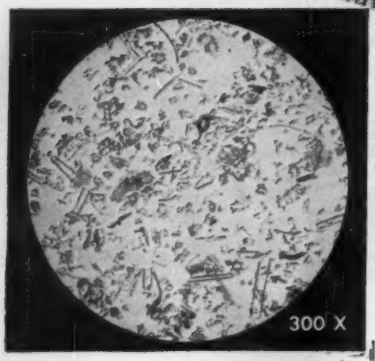
ELLIOTT Company
Jeannette, Penna.

PO-3

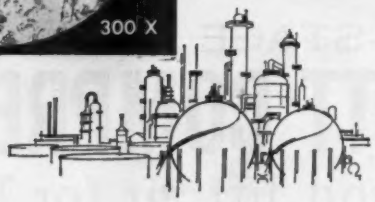


For fertilizer coating—Celite 379, a natural milled diatomite, provides the uniform conditioning needed to prevent caking of granular, mixed or prilled fertilizers—maintains good free-flow characteristics even after prolonged storage.

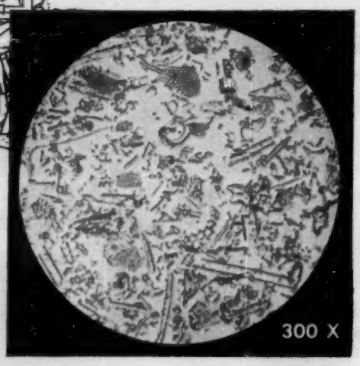




For catalyst carriers—Super Floss, finest particle size flux-calcined Celite grade, is used where a non-reactive porous silica support is needed. (Also available: special Celite supports in many preformed shapes for strength, high temperature stability, resistance to abrasion and attrition.)



As a paint-flatting agent—Celite 281, air-floated fines of flux-calcined diatomite, provides uniform and efficient flatting at low cost. Contributes to control of low angular sheen, durability, and faster drying.



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No matter which of the many available grades you choose, you can depend on a given volume of inert Celite* to retain its typical dry-powder characteristics even after absorbing its own weight of liquid.

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Other unique properties—extremely high bulk, irregular particle shape and large available surface area—ideally suit Celite to hundreds of mineral filler applications. It is produced with precision from the world's purest commercially available diatomite deposit. It offers a wide choice of grades, each carefully controlled for complete uniformity.

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*Celite is Johns-Manville's registered trademark for its diatomaceous silica products

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Top news stories and what they mean to CPI technical decision-makers

Chementator

Raw-materials scramble: firms vie for conflicting mineral rights

The chemical process industries are getting some first-hand experience with what economists have been describing as "our dwindling natural resources." In recent months, CPI firms have found that not only must they expect to face competition for the rights to develop a specific raw material on a given piece of property, they also must be prepared to battle for those rights with firms eager to exploit entirely different minerals on the same land.

Latest case in point: the recent squabble over the mineral rights to 9,445 acres of federal land along the Colorado River in Utah on the Grand and San Juan counties' line. Texas Gulf Sulphur last month obtained the go-ahead from the Interior Dept. to build a $30-million "deep" potash mine beneficiation complex on the property, at Cane Creek. But in order to get the OK, Texas Gulf had to do battle with the Rocky Mountain Oil and Gas Assn., which sought to keep the land available for oil and gas drilling.

The oil and gas people maintained that potash mining would be compatible with their operations. But Texas Gulf asserted that oil and gas drilling would constitute a great safety hazard to potash miners working some 3,000-ft. underground. And taking the necessary safety precautions would make Texas Gulf's potash operations uneconomical.

This case closely follows a similar hassle in which Stauffer Chemical was involved when it first attempted to build a soda-ash-from-trona plant at Green River, Wyo. (*Chementator*, Aug. 8, p. 53). In that instance, Stauffer's plans to develop the trona deposits on 5,000 acres of federal land were in competition with both a bid by Hill & Wagner, Denver geologists, to develop oil shale deposits on the property, and a Wyoming state and reclamation project. In the end, Stauffer obtained lease to the land by demonstrating that its operations wouldn't interfere with the state's reclamation plans. But the oil shale proposal, considered to be in conflict with trona mining, was scrapped.

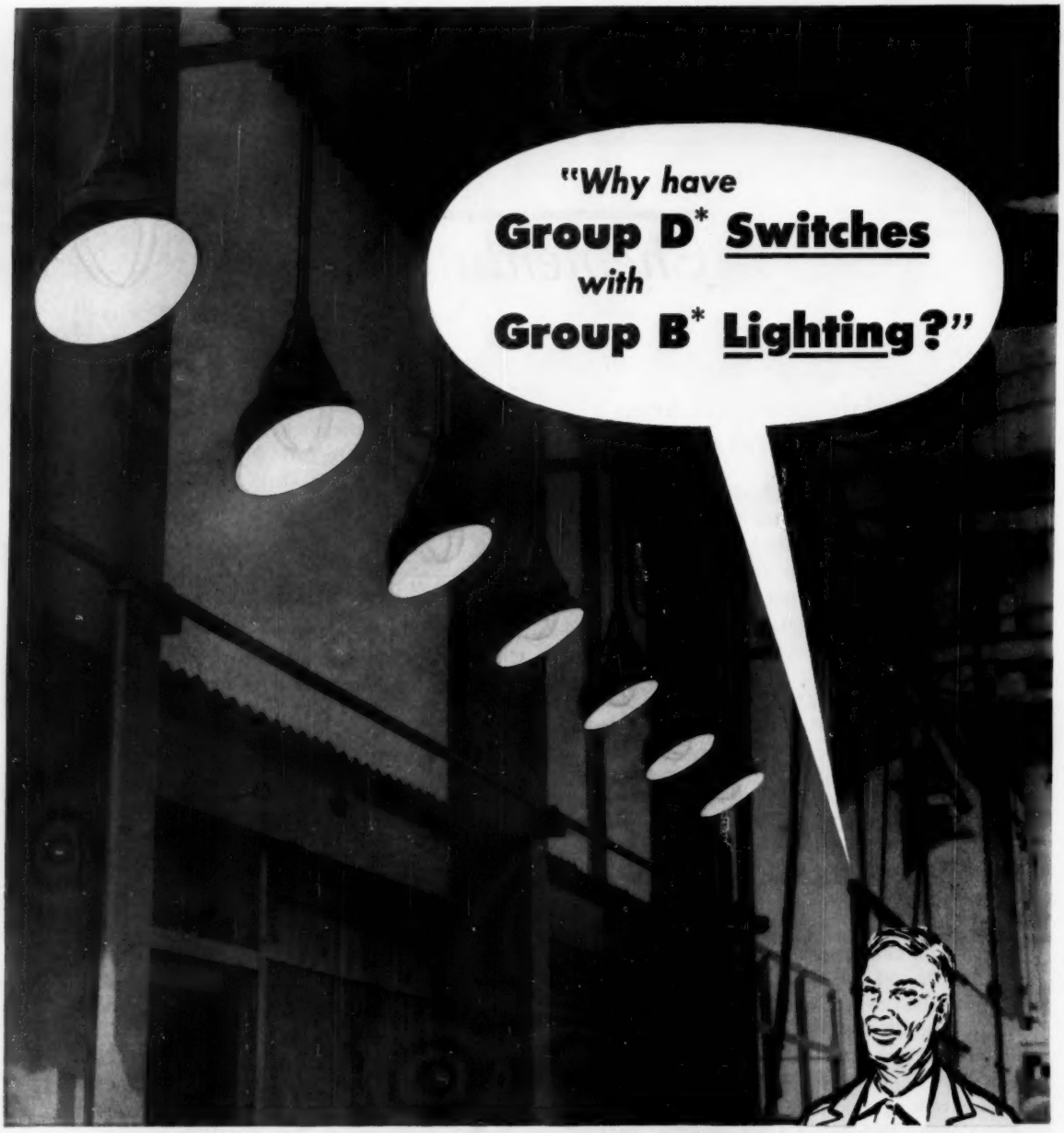
First plant using the Hydeal dealkylation process **(Chementator, *Oct.* 19, 1959, *p.* 98)** ***has quietly gone on stream at Silsbee, Tex. Unit belongs to South Hampton Co. (Houston), will produce 4-6 million gal./yr. of benzene from toluene.***

New organophosphorus chemicals kindle hopes for big markets

Two phosphorus-oriented companies are glowing with enthusiasm over new lines of organophosphorus materials, differing chemically but similar in their resistance to oxidation.

At the recent American Chemical Society meeting in New York, Monsanto's Gail H. Birum described a new reaction to combine halides of trivalent phosphorus with certain carbonyl compounds and esters of trivalent phosphorus acids. In the reaction, the halogen bond to the phosphorus is replaced by a phosphinyl-hydrocarbyloxy group, creating a new class of phosphorus compounds.

First job for Monsanto's new chemical family will be in flame retardants for resin systems. These particular compounds are made from phosphorus chlorides and bromides combined with aldehydes and trialkyl phosphites. Monsanto claims they provide the first economical way to impart flame resistance to polystyrene, polyolefins, acrylics and polyesters, for example, without damaging desir-



Why, indeed? As long as you're in a hydrogen area, there's just as much danger of explosion with one piece of equipment as there is with the other.

And the same goes for acetylene areas, too. *And* for all other pieces of electrical equipment in such an area . . . fixture hangers, seals, flexible couplings, junctions, push button stations.

Crouse-Hinds is the only single source for complete systems of UL-listed explosion-proof electrical equipment, no matter what the National Electrical Code Class or Group.

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able resin properties. Firm is introducing developmental quantities of six new flame retardants this month, made in its St. Louis, Mo., pilot plant.

In another area, Hooker Chemical is now producing commercial quantities of triphenylphosphite-derived compounds. These organophosphites are mixed into new types of stabilizer systems to retard oxidation in polyvinyl and polyolefin resins.

Hooker has a new multimillion-lb./yr. plant at Niagara Falls, N. Y., turning out four of these organophosphite stabilizers. In addition, firm is readying six more organophosphites for commercial exploitation in the near future.

Air Force has awarded Texaco a $1.3-million contract for study of the entire liquid propellant program and development of advanced liquid fuels. Texaco will look for storable liquids that pack a maximum amount of energy into a minimum amount of weight and space.

Outlook brightens slightly for petrochemical acetylene processes

Licensors of petrochemical acetylene processes, who had become gloomy when new plant orders did not follow the optimistic market predictions of a few years ago, are heartened by the news that Diamond Alkali is pushing full speed ahead with plans for a natural-gas-based acetylene plant near Houston, Tex. (estimated capacity: 35 million lb./yr.). Also on tap is a $50-million plant for Monochem (owned by Borden and U.S. Rubber) on the Gulf Coast to produce acetylene and vinyl chloride. And several other plants are now in preliminary negotiations.

Trade reports, which Diamond will not confirm, indicate that the Societe Belge de L'Azote process (*Chem. Eng.*, Oct. 1957, p. 144) has the inside track for the Diamond job. Reason: the SBA process calls for lower capital investment than the Badische Anilin- & Soda Fabrik route. And SBA, anxious to get established in the U. S. (one commercial plant is operating in France), commands a smaller royalty than BASF.

The Eastman process, geared exclusively to liquid feedstocks, will probably not be in the running for either of the two plants that are in advanced stages of negotiation. Although the process has been proved on a commercial scale in Germany, liquid feeds cannot compete with cheap natural gas in this country. Rising cost of natural gas, however, is narrowing the cost differential between competing feedstocks.

Latest score for engineering unions: one win, two defeats

Events of the past few months have seen the progress of engineering unions halted if not reversed. These three developments deserve special notice:

• The Engineers Assn. at Sperry was defeated in its attempt to affiliate with the International Union of Electrical Workers (*Chementator*, Sept. 5, p. 41). Vote, supervised by the National Labor Relations Board, was 1,724 to 1,509 against the AFL-CIO tieup.

Outcome was significant because the margin of defeat was provided by engineers who are not members of the union but who would have been represented by it in collective bargaining. In previous votes, these engineers had supported an all-engineer union, though not choosing to become members themselves. But they balked at affiliating with a trade union.

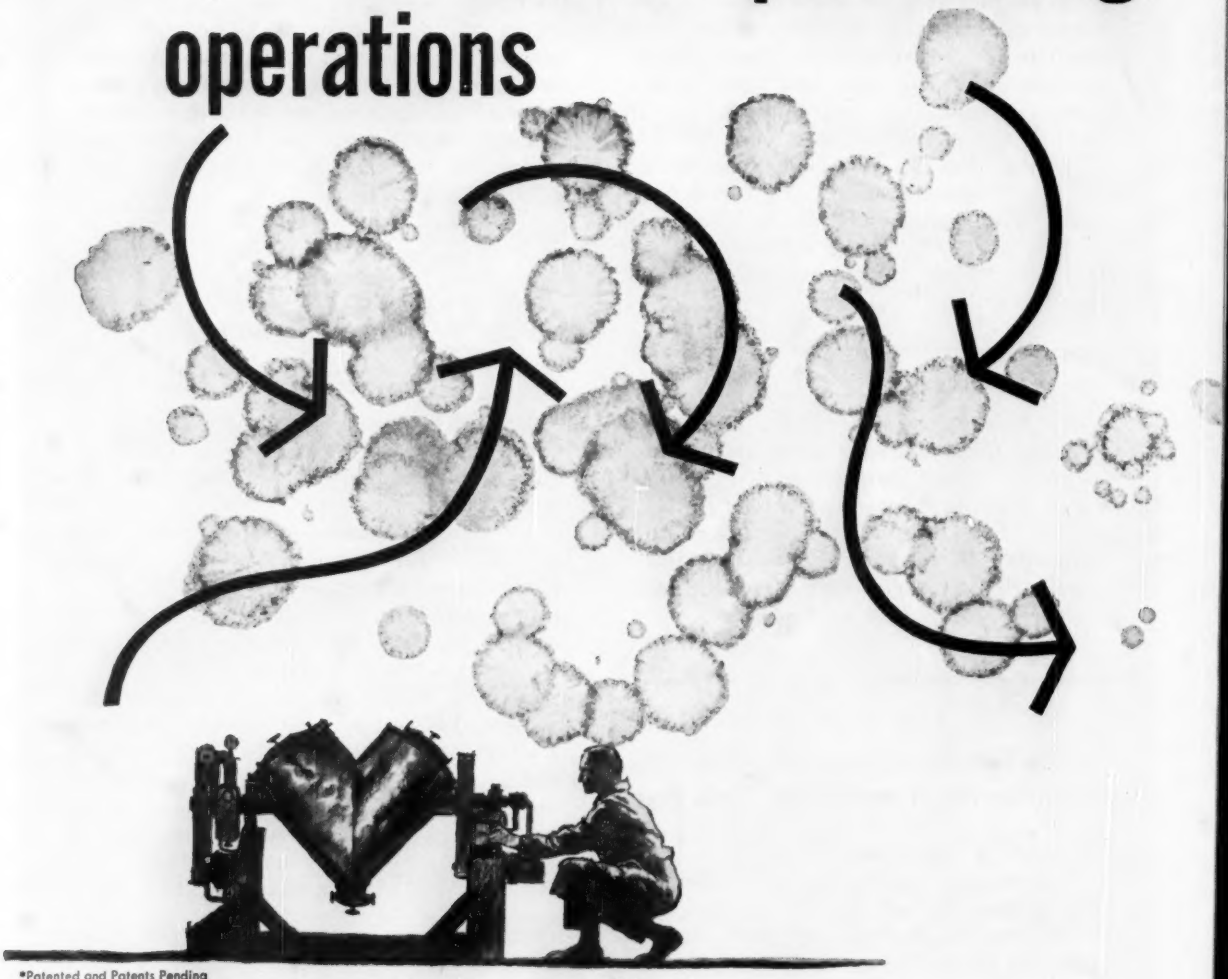
• The case at Boeing Aircraft (Seattle) involving the laying off of engineer Richard Dortch (*Chementator*, Mar. 7, p. 53) has been decided against Dortch by an outside arbitrator. The Seattle Professional Engineering Employees Assn. had contended that Dortch, who was ranked lowest in his group of mechanical engineers, should have been matched against every Boeing engineer before being laid off.

• Lone victory for engineering unions came when an arbitrator upheld the position of the Southern Calif. Professional Engineering Assn. that the 5% pay cut leveled by Douglas Aircraft (Los Angeles) violates their union contract (*Chementator*, May 30, p. 38).

(Continued on page 38)

new P-K solids-processor performs up to*

10 solids processing operations



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1. Precision gentle blending
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3. Liquid-solids blending
4. Granulation of solids
5. Vacuum drying of solids
6. Coating of solids
7. Heat sterilization of solids
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(Many of these operations can be performed under vacuum)

The P-K Solids Processor gives you many exclusive opportunities for savings — in *quality control, equipment, time, manpower, space.* It not only combines vacuum drying and liquid-solids blending in one fully packaged unit for the first time, but it also performs in a simple sequence more operations in a single unit than ever before possible.

DRY BLENDING— With this latest P-K "Twin-Shell" development you can tumble solids to give gentle precision blending. This may be done under vacuum or atmospheric conditions, in inert or sterilizing gas, with heat in jacket up 200°F., or with cooling through jacketed shell. If required, intensifier bar action breaks up agglomerates or gives uniform dispersion of difficult materials such as pigments.

LIQUID DISPERSION, GRANULATING — You can disperse controlled amounts of liquid uniformly into solids. Fluids of any viscosity can be handled.

Dispersion can be sufficiently intimate to provide a lump-free powder. Or you can regulate it to produce granulations of controlled size. As in dry blending, you can conduct these steps under vacuum or atmospheric conditions, in inert or sterilizing gas, or with cooling or heating through jacketed shell.

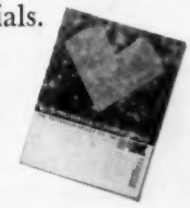
VACUUM DRYING— You can use the P-K Solids-Processor to vacuum dry heat sensitive materials. A separately actuated agitator speeds drying to a finished fine powder or controlled granule. In final stages of drying, direct hot air or gas can be introduced.

All P-K Solids-Processor systems are completely packaged. Available in standardized models with charge capacities from one to fifty cubic feet.

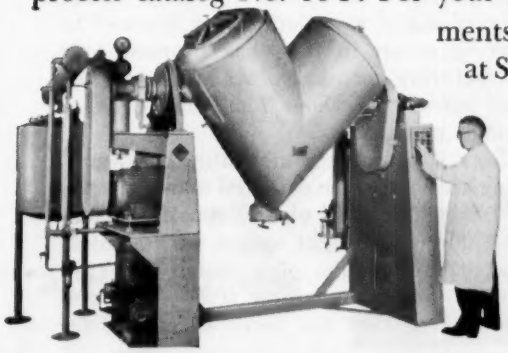
PRE-TEST SERVICES — A production model of the new Solids-Processor is available for pre-testing at our Pre-Test Laboratory in East Stroudsburg. Standard, intensifier and liquid-solids "Twin-Shell" Blenders are also available . . . as are packaged vacuum tumble dryers (conical type) and ribbon blenders.

Using your materials, P-K engineers can demonstrate things impossible to see without pilot study . . . work out subtle variables in blending, granulating, drying . . . indicate scale-up results and operational procedures . . . and predict savings in materials, labor, investment.

You'll gain the most by making the trip personally to East Stroudsburg. Your guidance will be helpful. If you cannot make the trip, send your materials.



All P-K equipment is completely described in P-K's new process catalog No. 16-P. For your copy or to make pre-test arrangements, write or phone George Sweitzer at Stroudsburg, Hamilton 1-7500.



Patterson Kelley

Chemical and Process Equipment Division
112 Burson Street, East Stroudsburg, Pa.

Douglas says it will restore all salaries retroactively, even though the arbiter's decision affected only the 210 SCPEA members who had filed grievances.

Market for copper sulfate could double from present 40,000-ton/yr. level if the process developed by Republic Chemical Corp. (New York) catches on. Firm discovered that adding $CuSO_4$ to asphalts and bituminous materials increases formation of long-chain asphaltenes, reducing tendency to flow at high temperature and brittleness at low temperature.

Japanese polymer route scaled up despite possible patent wrangle

Despite the risk of a patent-infringement battle, the Japanese firm Tokuyama Soda is moving ahead with plans for commercializing its new "spark-discharge" polypropylene process (*Chementator*, Sept. 5, p. 48). The company last month revealed that it has brought on stream a 1-ton/day pilot plant. And plans are now in the works for building a 10,000-ton/yr. facility early next year.

Tokuyama Soda has obtained five Japanese patents on its new process. But there's a strong possibility that Montecatini, a pioneer in polypropylene processing, will claim that Tokuyama's route infringes its patented know-how. The Italian firm, which has licensed its process to two large Japanese chemical groups,* is already involved in just such a patent suit with AviSun because that company has sought to license its polypropylene know-how to Shin Nippon Chisso.

The principal point at issue with Tokuyama from Montecatini's view would be the Japanese firm's catalyst system. Tokuyama uses a metal halide such as titanium tetrachloride, a deoxidation agent such as powdered aluminum and an alkyl halide such as ethylene bromide. Superficially, at least, this catalyst system is quite similar to that covered by Montecatini's several Japanese patents.

But Tokuyama makes its claim to a new and different process chiefly on the basis of the 1-300 va. spark discharge that it uses to enhance the effectiveness of the catalyst system and boost yields. And it isn't alone in this view. A patent agency examiner expressed the opinion to *CE*'s Tokyo correspondent that "to treat propylene molecules by spark discharge has, heretofore, never occurred to anyone."

Aluminum producers stake new claims in nation's oil fields

Prospecting new uses for today's plentiful aluminum stocks, producers Reynolds and Alcoa have struck pay dirt in previously unexplored territory: oil and gas fields. The firms have announced, almost simultaneously, successful use of aluminum pellets in oil well fracturing, replacing sand now used. And Reynolds, in collaboration with an unidentified oil producer is just starting to drill the first oil well using aluminum drill pipe exclusively.

In fracture experiments, Reynolds and Atlantic Refining used aluminum pellets in 11 wells in five states to open formations and increase production as much as 900%. One well in the Maquoketa formation near Great Bend, Kan., for example, increased from 5 to 48 bbl./day. Conventional sand fracturing would have yielded only a 2-bbl./day increase.

Alcoa, working with the Tulsa Research Center of Pan American Petroleum Corp., makes the additional finding that an unspecified aluminum alloy is even more efficient than pure aluminum pellets in opening formations, although these lab results have not yet been proved in the field. But commercialization of Alcoa's findings may be hindered because a patent on use of aluminum fracturing pellets has been issued to Atlantic and licensed to Reynolds, which in turn has licensed four well-fracturing companies. At stake is a potential market for about 7 million lb./yr. of aluminum pellets.

Less advanced commercially, but representing an even larger potential market, is the use of aluminum drill pipe. Reynolds is combining aluminum's light weight with a thick-at-end, thin-in-middle pipe design for even greater weight savings over steel pipe. Company believes that the test-well now under

* Mitsui Chemical-Toyo Rayon; Mitsubishi Petrochemical-Mitsubishi Rayon.

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way will bear out its contention that operational savings resulting from the lighter drill string will more than make up for the higher initial cost of the aluminum pipe.

CPI firms schedule heavy capital spending abroad in 1960 and 1961

Overseas marketplaces continue to hold a strong allure for the U.S. chemical process industries. According to a just-completed survey by McGraw-Hill's Dept. of Economics, the major CPI firms are making and planning increasingly heavy capital investments in foreign countries this year and next.

Firms covered by the survey, which will be analyzed in an upcoming issue of *Chemical Engineering*, account for roughly 75% of the total capital expenditures by American industry outside the continental U.S.

Manufacturers of chemicals and allied products report that they expect to spend about $246 million in 1960 on overseas property, plant and equipment—some 29% more than they did in 1959. And plans call for a foreign capital bill over $285 million in 1961.

The rubber industry predicts a 4% hike over 1959 to $57 million in 1960, has slated nearly $66 million worth of overseas spending for 1961. Petroleum estimates that its outlays abroad this year will be 11% higher, at $1.27 billion, than last year, though they will be trimmed to $1.24 billion in 1961. Pulp and paper plans to hold its 1960 foreign investments at 1959's $31 million, but will step them up to over $32 million next year. Stone, clay and glass will top 1959 spending level this year by an impressive 37%, with outlays of nearly $18 million, then expects to cut back to under $15 million in 1961.

Computer control will be aided by data-transmission networks

At the Instrument Society of America's 15th annual meeting, in New York, Daystrom, Inc., demonstrated a new use for computer networks (*Chementator*, Apr. 18, p. 81).

Daystrom's System Div. engineers showed hardware that permits long-distance programming and servicing of the company's control computers. The device—called "Come Home" by the firm—uses leased phone lines and American Tel & Tel's digital subset to transmit information in the two-way net between Daystrom's office and customer's computer.

The remote servicing device might be used in a couple of ways:

- If a malfunction occurs in the computer, the alerted maintenance man—who is perhaps 2-3,000 miles away—can run a test program into the computer and locate source of trouble, say a circuitry card.
- If it's necessary to change the computer program because of process changes or greater process understanding, the entire program can be revised by long distance.

There seem to be advantages to such a system for most CPI firms: contracts at computer-controlled plants have required a computer service engineer on call at the plant site. But many chemical firms dislike having outsiders working intimately with their processes. Remote servicing solves this problem.

Scheduled for installation at end of the year, "Come Home" will first be used with a Kansas Gas & Light Co. generating-station computer.

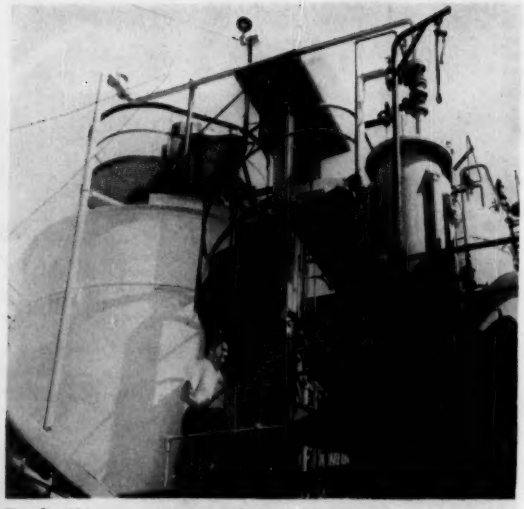
Research and development briefs

Accurate measurement of reaction rates through changes in sound waves has been developed by physicist Harvey Blend at UCLA. Through a combination of optical, acoustical and electronic techniques, frequency changes as small as one cycle in one million can be detected. By subjecting reactants to short bursts of sound waves (to eliminate echoes), Blend hopes to gain greater insight into the mechanism of chemical reactions.

Alumina from clays and aluminuous laterites that cannot be treated by the Bayer process is being produced experimentally via an acid route developed by Australia's Commonwealth Scientific & Industrial Research Organization (Melbourne). Results of laboratory tests indicate that reagent costs are lower than in the conventional Bayer process. Main problem now being attacked is high capital cost of corrosion-resistant equipment needed to withstand the acid conditions.

For more on DEVELOPMENTS....42

Incubation starts with test tube, ends with 6-liter flask.



Production moves step-wise to 12,000-gal. tank (left).

FLASK-TANK SETUP NOW TURNS OUT

West Coast company perfects process for manufacture of microbial insecticide that's lethal to leaf-chewing pests, yet nontoxic to plants and animals. Test-tube to 12,000-gal.-tank setup turns out 2 tons/day.

Application of good chemical engineering techniques in the fermentation field has enabled Bioferm Corp., Wasco, Calif., to make a major breakthrough in crop pest control—commercial production of the microbial insecticide Thuricide.

It is composed of spores of *B. thuringiensis Berliner*, a microorganism that induces disease in certain insects, yet is not toxic to plants and animals.

The product is now being used for control of cabbage loopers, imported cabbageworms and diamondback moth larvae on cauliflower, cabbage and lettuce. But, recently compiled field data suggest many promising uses for other vegetables, field crops, fruits, forest trees, lawns and tobacco.

Interesting, here, are the results of a test conducted by USDA scientists, in which an aerial application of the insecticide to deciduous forests in Vermont resulted in excellent control of gypsy moth caterpillars without endangering wildlife.

To make the insecticide practical, you have to produce a resistant spore form that remains virulent to insects while stored as a powder, or when exposed to air, heat and sunlight on plant surfaces.

▶ **Starts in Test Tube**—The pure culture, obtained by Bioferm from Prof. D. A. Steinhaus at U. of Calif., Berkeley, is a direct descendant of one originally isolated in Germany in 1911.

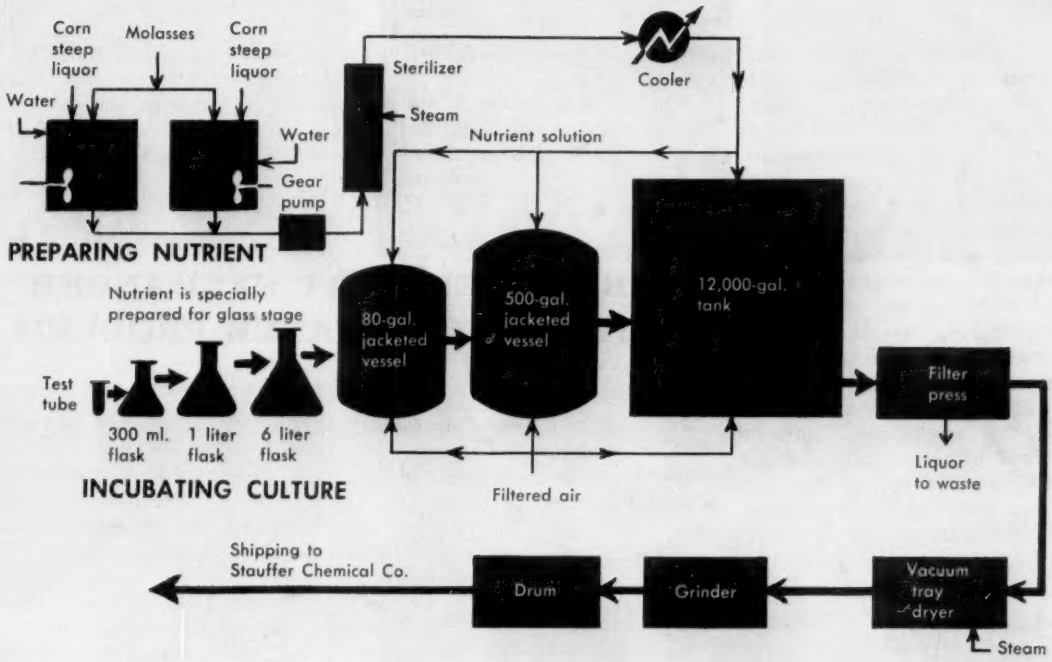
It is incubated, starting with a test tube and working up through flasks of 300 ml., 1 liter and 6 liters, respectively. Since it is made up of growing bacteria, there isn't anything resembling a material balance; just keep adding proper nutrients, and control temperature between 28 and 30 C., and the spores keep multiplying.

Periodic shaking of glassware is required for aeration. Total time of this bench period is only a few hours.

▶ **Then, Large Tanks**—From the 6-liter flask, gravity transfer is made to an 80-gal., 3-ft.-dia., 69-in.-tall pressure vessel. Nutrients are introduced here, as well as filtered air that serves the dual purpose of supplying oxygen and agitating the culture.

Next, the broth is transferred to a 500-gal., 6-ft.-tall pressure vessel. Here, too, nutrient solution is added and air sparging used. Both of the tanks are jacketed and use water or steam, as required, to maintain a constant 28-30 C. temperature.

When growth is far enough along, the broth is transferred to a 12-ft.-dia., 12,000-gal. production vessel. It is in this tank that complete sporulation takes place—the final change, from a vegetative growth



FIRST "BUG-KILL-BUG" INSECTICIDE

to one having at least 95% spores.

This vessel, unlike the previous ones, isn't jacketed. Cooling is done by spraying water on exterior of tank. In the hot, dry atmosphere of the San Joaquin Valley, this amounts to falling-film evaporative cooling.

Transfer from vessel to vessel is by a standard technique for sterile materials called "inoculum transfer." It is done with air pressure and mild-steel piping. Incidentally, Bioferm engineers determined that mild steel could be used for all of the production equipment. This is one of the keys to the economic success of the process.

▶ **Preparing Nutrient Solution** — Molasses (for sugar) and corn-steep liquor (for protein) are mixed with water in 2,600-gal. open wooden tanks equipped with regular side-entering agitators. Two tanks are used, one for making up the nutrient solution, the other for storing and feeding it to processing.

As required, nutrient solution is transferred by gear pump to a continuous sterilizer. This unit is actually a pipeline reactor in which the liquor has a 20-sec. residence time and reaches 260 F. Next, it passes through a fin-tubed, water-cooled heat-exchanger that reduces the temperature to 28-30 C., then goes to the production vessels.

After final sporulation (time lapse from test tube to complete spore forming is 7-10 days), broth is blown from the large vessel to a plate-and-frame filter press. Fast filtration is required in order to get the spores as dry as possible within a short time. Diatomaceous earth is used as a filter aid and the spent broth is discarded (Bioferm hasn't yet found a use for it).

Solid cake is removed from the filter and placed in trays of a vacuum dryer that uses live steam and keeps the temperature below 50 C.

When dry, the product is ground to a powder, blended for uniform potency, mixed with clay and packed in drums for shipment to Stauffer Chemical Co., exclusive distributor of the insecticide. Stauffer does the final formulation, using wetting agents and other additives to produce wettable powders, dusts or granular products. Bioferm's present production is 2 tons/day of concentrate.

▶ **Quality-Control Emphasized** — Control is exercised at all times, with emphasis on actual spore counts and identification of contaminants as well as growth of spores. Variables watched are temperature, pH and turbidity. Latter is a measure of growth rate. Spore counts and contaminant identification are made by microscopic checks and streak techniques.

Unlike most insecticide manufacturers who test their final product by normal chemical methods, Bioferm actually measures the activity of each batch of Thuricide against live insects. Company raises its own insects and their food, and runs the tests under controlled conditions.

Insects used are of the same size, age and history. Spore content, temperature and humidity are kept constant. Number of dead insects is observed daily. This gives dosage mortality curves, a measure of the insecticide's activity.

Final batch release is dependent on clearance in a pharmaceutical-type mouse safety test. In this test, one million spores must have no adverse effect on a 17 g. white mouse.

Thuricide doesn't replace other insecticides, but fits into the overall picture. It doesn't compete with endrin on lettuce, for instance, because endrin can only be used until edible parts of the plant form. Thuricide takes over at that point and may be used until the plant is harvested.

Or it may be used in combination with other insecticides. Thuricide is mixed with chemicals that kill aphids, being a specific for leaf-chewing moth and butterfly larvae. It doesn't affect sucking insects, is completely safe to use around bees or insect predators.—*MDR, AVG*

Price Cuts Develop New Markets for Dialdehyde

Union Carbide Chemicals has slashed 6¢ across the board on the price of glutaraldehyde, bringing price down to 13¢/lb. in tank-car lots. This makes it the cheapest dialdehyde now commercially available, says Carbide.

Main impetus behind the price cut is a new leather-tanning process developed at the U. S. Dept. of Agriculture's Wyndmoor, Pa., laboratories. USDA research shows that glutaraldehyde is excellent for tanning soft leather of the type used in gloves and garments. When used as the sole tanning agent, glutaraldehyde produces leathers with a good finish, soft feel, and good resistance to perspiration.

Several tanners are now investigating the process in commercial operations. Preliminary results indicate that glutaraldehyde is compatible with other tanning materials, can also be used in combination with chrome and vegetable tannages. Carbide hopes that the price cut will provide the push needed to persuade tanners to adopt the glutaraldehyde process—and at the same time move this dialdehyde into the big-volume heavy-chemical category.

New postings are also expected to stimulate uses outside the leather industry; for example, as a bactericide for control of sulfate-reducing bacteria during water floods in secondary oil recovery, and as an insolubilizing agent for protein and polyhydroxy compounds.

AIR-COOLED HEAT EXCHANGER SOLVES FRESH-WATER PROBLEM

Inclusion of a special air-cooled heat exchanger in its recently installed Unifiner has enabled Cosden Petroleum Corp., Big Spring, Tex., to:

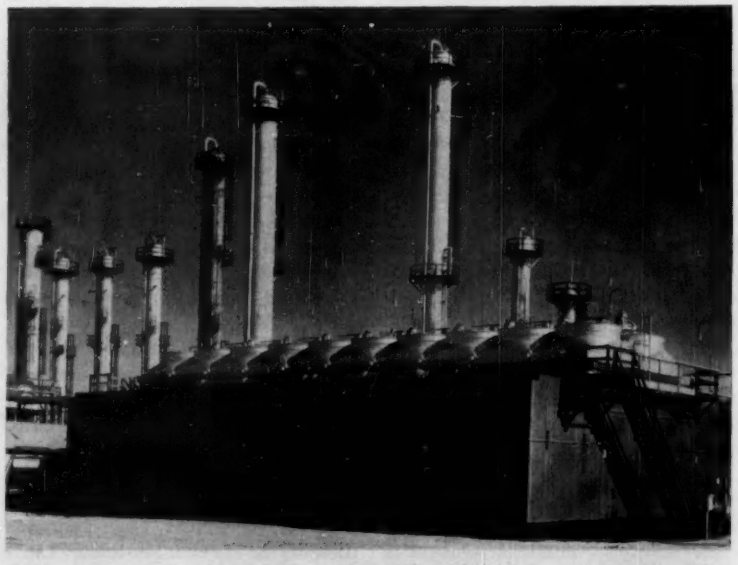
- Substitute waste process water for fresh water (which costs 18½¢/1,000 gal.) to cool the air supplied to the unit.
- Overcome water treating problems.
- Eliminate need for winterizing its cooling system when temperatures drop to 20F. or lower.

Cosden's Unifiner which went on stream in Dec. 1959, is fed all of the company's straight-run gasolines—about 8,500 bbl./day. The non-olefin gases from the refinery are processed through a light-ends unit (towers in background of photo below).

Because of the high temperatures required, all of the reboilers are heated by direct-fired gas furnaces. Reactor charge heater temperature is 650 F.

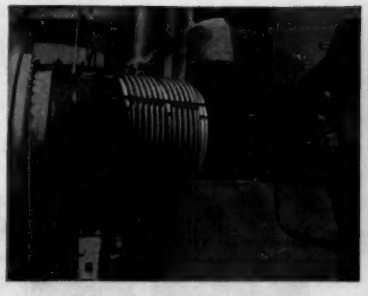
▶**Humidified Air Turns Trick**—Heat removal from the Unifiner is accomplished with a cooling unit (foreground) that employs circulating water solely to humidify and cool atmospheric air before it is used to cool streams fed to the unit.

At Cosden, 3,500 gpm. of water are circulated. Makeup is waste process water from a sump serving other units, after hydrocarbons are separated out. This water contains traces of hydrocarbons, styrene and



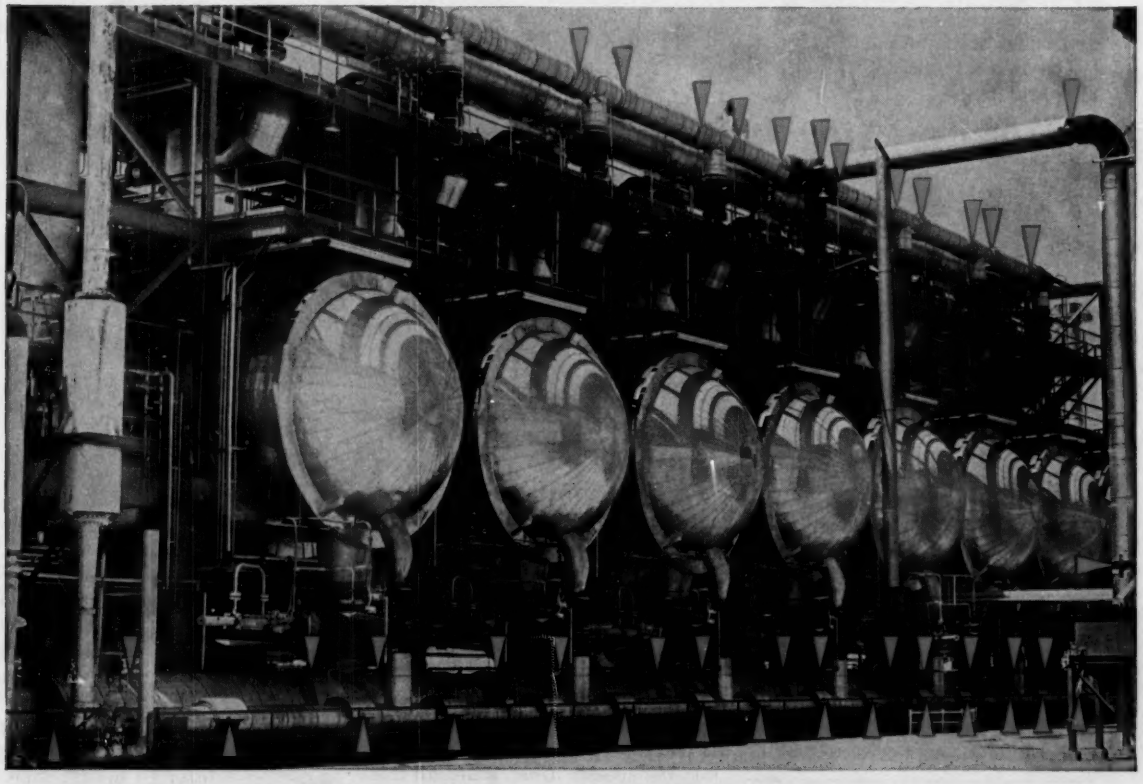
Exchanger comprises ten cooling units, each with two fans driven by 10-hp. motors. Exterior siding is of fiber-glass polyester-resin plastic.

85½ in. dia. expansion joint connecting quench and pre-quench towers. Pinned structural ties permit expansion joint to absorb axial and differential vertical movement.



48 in. dia. expansion joint at compressor discharge. Double bellows permit large axial movement. Internal sleeve guide provides for stability, minimum pressure drop.

54 in. dia. hinged expansion joints in loop to pre-quench tower. They absorb 5⅛ in. vertical expansion and 7⅜ in. horizontal expansion due to 1200°F temperature in reactor header.



125 ZALLEA EXPANSION JOINTS, 125 demands for maximum reliability

Expansion joints, specially engineered and designed by Zallea, solve problems of space, heat and flow for Odessa Butadiene Co., Odessa, Texas.

Large-diameter piping (up to 72 in. dia.), with short, straight runs and critical flow conditions, posed new design problems. High temperature operation (1200°F) required minimum loading on sensitive equipment. Open-air construction, with few load carrying members dictated maximum stability of expansion joints with minimum use of external guides and anchors to support pipe weight and resist wind loading.

To solve these problems called for a competent, close-working team of process, piping and structural engineers from Fluor Corp. Ltd., design engineers from Odessa Butadiene Co., and application engineers from Zallea.

Result: A compact, reliable piping-expansion joint system that permitted containment of an efficient, 50,000 ton per year unit in an area whose largest dimension is a few hundred feet.

This is another example of how Zallea experience in handling critical, complex Expansion Joint applications can save time and money. For more facts, call us . . . or write for catalog 56.

ZALLEA BROTHERS, Taylor and Locust Sts., Wilmington 99, Del.

Zallea **FOR MAXIMUM RELIABILITY**

WORLD'S LARGEST MANUFACTURERS OF EXPANSION JOINTS

other materials, but no acid, caustic or phenolic matter. It is not suitable for re-use as process water, and is normally sent to open-air-evaporation waste disposal ponds. Its use with the cooler helps reduce the volume of water to be evaporated in the ponds.

► **Cools Four Streams**—There are ten units in the cooler, each with two fans. Fans are 8 ft. in dia., and half of them have variable-pitch blades, so outlet temperatures can be controlled. This control is continuous and automatic.

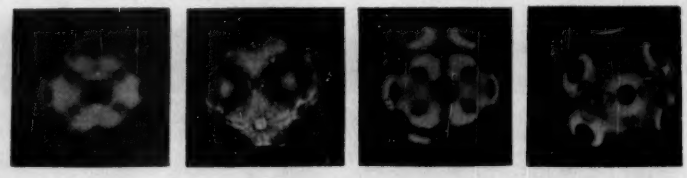
The four streams cooled in the unit are:

	Duty	Inlet Temp. Deg. F.	Units In Service
Unifiner reactor effluent	11.3	235	3
Debutanizer condensate	12.1	140	5
Depropanizer condensate	3.5	120	1½
Absorber lean-oil cooler	1.5	175	½

Total duty of unit is 28.4 × 10^6 Btu./hr. Outlet temperature of streams is approximately 100 F. Unit was designed for a maximum cooling air temperature of 80 F., and maximum air inlet temperature of 105 F. When ambient air temperature drops below 80 F., water circulation is stopped.

Only limitation to the unit is its inability to approach wet-bulb temperature closer than 20-25 deg. This makes its operation uneconomical in areas having higher humidity than West Texas, and where water costs are less.—THA, AVG

Crystal changes give clue to mysteries of catalysis



Photographs of a tungsten crystal, taken with the aid of an emission microscope, are giving researchers at Royal Dutch/Shell in Amsterdam, Holland, a new insight into catalysis. In order for a catalyst to function, molecules must be adsorbed on the catalyst surface; mechanism of this adsorption and interaction of molecules on the surface can be viewed with the emission microscope. Photo at the left, above, shows a tungsten crystal magnified about a million times. In the second photo, the crystal surface is covered with four to six ions, which cause the emission to increase sharply. The crystal has been heated to 200 C., third photo, causing the ions to move to sites where the energy gain is the largest. At 450 C., fourth photo, the reorientation has progressed further, producing striking symmetry. The field emission microscope operates on the principle that most substances will emit electrons when a high voltage is applied to their surface. If these electrons are focused on a fluorescent tube, the emission pattern is reproduced, as in television tube.

Dust-Counter Moves To the Battlefield

A new method for detecting personnel and vehicle movements near a battle area has been developed by Armour Research Foundation, Chicago. The technique depends on measurements of concentration and size distribution of dust particles in the air, utilizing a particle counter invented by Armour.

With this device, armies can maintain battlefield surveillance of a remote area: a miniature particle counter mounted in a drone aircraft, or a remotely controlled counter placed near a vital road junction, for example, could monitor enemy troop movements.

Once the type of ground and local dust makeup is known, readings gathered by the particle counters can be translated into the number of troops and vehicles that are moving in a specific area. When all this information is assembled and combined with known facts about the enemy, it gives an accurate picture of enemy activity.

The Armour correlation technique evolved through a series of projects for various sponsors, centering around the particle counter. These included analyses of "clean room" assembly facilities for gyroscopes and other sensitive instruments. While evaluating the statistical data from these projects, the foundation's scientists were able to correlate variations in dust level and dust particle size with movements of workers and machinery.

Plastic Bests Metal As Rocket Casing

The Air Force has selected Hercules Powder as the producer of the third-stage rocket engine for the Minuteman ICBM, thereby giving plastic an endorsement over metal for rocket casings. Hercules landed the contract with a design calling for an engine enclosed in Spiralloy glass-fiber-reinforced epoxy. Aerojet General, which had also been competing for the contract, had proposed using a titanium alloy for the third-stage casing (*Chementator*, July 25, p. 55).

Hercules' third-stage motor contains these features in addition to the high-strength epoxy shell: an unidentified solid propellant "with the highest specific impulse of any measured to date"; pivot nozzles used for thrust vectoring; thrust termination device that enables the range to be controlled and accurately programmed; lightweight nozzles made of "non-eroding materials."

THE NEW CHEMICAL ENGINEERING: DETAILS OF PROGRAM FOR CE-MRI MEETING

Conference in Kansas City, November 29-30, will be sponsored by Midwest Research Institute and Chemical Engineering *to promote interest among CPI engineers in new disciplines and new engineering tools.*

The program shown at right seems sure to draw process industry engineers to Kansas City, Mo., at the end of November. Designed so that chemical engineers can find their way to the help that new technology can give them, the unique meeting offers "novices" a chance to hear and question industry and academic specialists.

Recognizing the assistance that peripheral disciplines are giving to traditional chemical engineering areas of responsibility, *Chemical Engineering* and Midwest Research Institute have organized the meeting for maximum benefit to participants:

- No simultaneous sessions.
- Preprints of papers will be given to all registrants.
- Ample time for discussion of papers is planned.

▶ **Briefing the Program** — Three general areas are covered in this program: the new chemistry, the new mathematics and new engineering tools.

One paper in math and chemistry sessions will survey and review aspects of each discipline that are important to chemical engineers. Other papers in the initial-day sessions emphasize particularly important specifics.

Second-day program is about engineering tools, and here will be found definition for some important work that exists for many only as "glamor" words. Key men will find key ideas at Kansas City!

Conference on The New Chemical Engineering

Hotel Muehlebach, Kansas City, Mo., November 29 and 30, 1960

Cosponsored by

MIDWEST RESEARCH INSTITUTE and CHEMICAL ENGINEERING MAGAZINE

This two-day conference will consist of four technical sessions with a total of ten papers, plus two lunches, a reception and cocktail party, a banquet and a tour. The conference fee of $50 ($45 for those who preregister by Nov. 21) will cover the sessions, lunches, cocktail party, banquet, tour and a set of preprints of the technical papers that will be supplied to registrants in a souvenir briefcase.

The Program

Registration desk open from 6 PM November 28 to 4 PM November 30.

TUESDAY, NOVEMBER 29

9:30 AM—First Session

Welcome, *Max H. Thornton, Midwest Research Institute*
Keynote Speech, *S. D. Kirkpatrick, McGraw-Hill Book Co.*
The New Chemistry
Survey of The New Chemistry, *Norman Hackerman, Univ. of Texas*
Solid-State Chemistry, *Rowland Johnson, Texas Instruments, Inc.*

12:15 PM—Lunch

1:45 PM—Second Session

The New Mathematics
New Uses for Mathematics, *J. S. Dahler, Univ. of Minnesota*
Mathematics of Control Loops, *T. J. Williams, Monsanto Chemical Co.*
Numerical Analysis, *Yudell Luke, Midwest Research Institute*

6:15 PM—Reception and Cocktail Party

7:00 PM—Banquet

Banquet speech by a nationally recognized authority on a subject of current and great interest to all engineers in the Space Age.

WEDNESDAY, NOVEMBER 30

9:00 AM—Third Session

New Tools of the Engineer—I
Systems Engineering, *T. C. Wherry, Phillips Petroleum Co.*
Process Kinetics, *Henry Eyring, Univ. of Utah*
Information Retrieval, *J. W. Perry, Univ. of Arizona*

12:15 PM—Lunch

1:30 PM—Fourth Session

New Tools of the Engineer—II
Process Statistics, *T. L. Koehler, American Cyanamid Co.*
Operations Research, *James C. Hetrick, A. D. Little, Inc.*

4:00 PM—Guided tour of Midwest Research Institute (Buses leave hotel).

5:00 PM—Tour ends, registrants returned to hotel.

POWELL
CORROSION-RESISTANT
VALVES

Performance makes the world of difference

Fig. 2474BSW—Bell-o-Seal (Packless) O.S.& Y. Globe Valve for 150 pounds W.P. Available in various corrosion-resisting metals and alloys. Can be furnished with screwed, flanged, socket welding or butt welding ends.

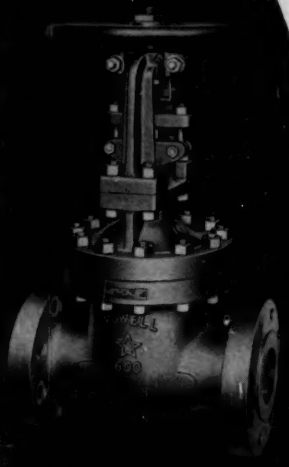
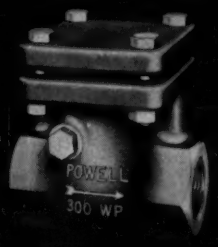


Fig. 6003SS—Large Stainless Steel Gate Valve for 600 pounds W.P. Face to face and end flange dimensions conform to latest standards. Sizes ½" to 24", inclusive.

Fig. 2345—Stainless Steel, screwed end Swing Check Valve for 300 pounds W.P. Available also with flanged or socket welding ends. Face to face and end flange dimensions of flanged end valves conform to latest standards.



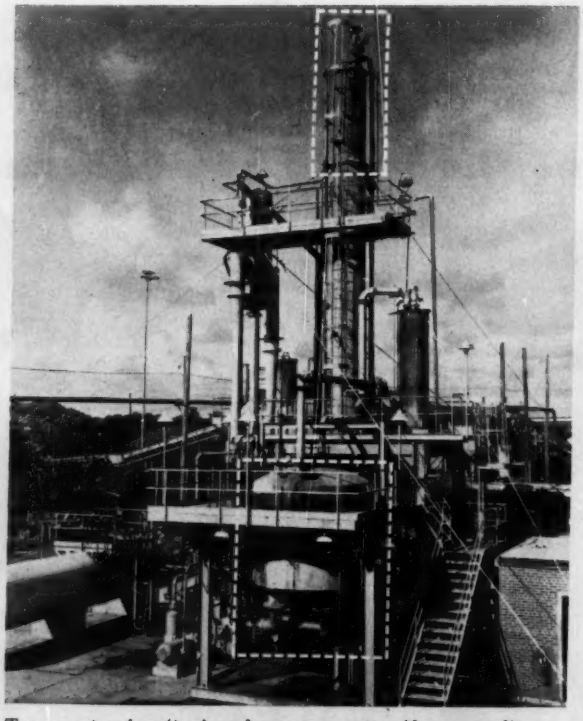
Powell pure metal and special alloy valves have long been recognized by the Chemical and Process Industries as leaders in the field of corrosion-resistant flow control equipment.

The result of painstaking research; years of experience in modern foundry practice, pattern limitations, and machining possibilities, Powell Corrosion-Resistant valves can be depended upon for long uninterrupted service, with little or no maintenance, and freedom from contamination of end product.

They are available in a wide selection of materials ranging from "A" to "Z" (Aluminum to Zirconium) to handle practically every known corrosive media. For complete details contact your nearby Powell Valve Distributor—or write directly to us.

Powell . . . world's largest family of valves

THE WM. POWELL COMPANY • DEPENDABLE VALVES SINCE 1846 • CINCINNATI 22, OHIO



Tower extension (top) and new generator (foreground) were major changes in chlorine dioxide plant expansion.

UNIQUE TOWER-LINING SCHEME CUTS EXPANSION DOWNTIME

When Buckeye Cellulose Corp. recently doubled the chlorine dioxide capacity of its Foley, Fla., plant to meet increasing demand for brighter (better light-reflecting surface) pulps, it was faced with the dilemma of continuing production during the expansion.

But one change in the equipment —increasing the height of the absorption tower from 20 to 30 ft.— posed a major problem.

Normal construction procedure would have been to bolt the extension on the top flange of the existing tower, then line it with acid-resistant brick. This would have necessitated an extended shutdown.

Instead, Buckeye inserted an impervious membrane and brick lining in the steel shell of the extension while it lay horizontally on the ground. Only after the extension was lined and ready for service was the head of the old column removed.

▶**Quick Installation** — Then the new section was hoisted in place and bolted to the old column. Packing was added, the head placed on top of the new section, and production resumed.

To prevent corrosion at the joint between old and new sections, membranes from each were turned out between the flange faces. That the brick lining held tight during the jostling and jarring of erection is a tribute to a new polyester resin cement that was used in preparing the lining.

Only major addition of new process equipment was a generator (reactor) that was paired with the original one to create a two-stage process. Since such systems have proved more efficient than single-stage ones, Buckeye expects to get better raw-material utilization.

Because gaseous ClO_2 is highly corrosive, most metals and many plastics are not suitable for process piping. The new facility uses Fiberglas-reinforced polyester pipe for the main gas line. Glass-lined steel is commonly used for this service.

▶**OM Process** — Buckeye's Foley plant was one of the first units in the pulp and paper industry to make ClO_2 by the Olin Mathieson process. Raw materials are sodium chlorate, sulfuric acid and sulfur dioxide. All are combined in the primary generator where gaseous ClO_2 is produced exothermically.

Gas is scrubbed with incoming sodium chlorate, then put into water solution by countercurrent contact in the packed absorption column. Liquid product from the primary generator is contacted with more sulfur dioxide in the secondary generator to maximize conversion. About 95% of the plant byproducts, largely sodium-sulfur compounds, are recovered.—FCP

A-Heat Into Electricity In Efficient New Cell

In a development that brings researchers one step closer to realizing practical conversion of nuclear energy directly into electricity, General Atomic Div. of General Dynamics Corp. announces it has run a cesium-cell thermionic converter at a power level of 90 watts. This is about ten times the power output of any previously described thermionic device.

In tests conducted at General Atomic's San Diego, Calif., laboratories, the high-power cesium cell gave a power density of 21 w./sq. cm. Conversion of fission energy to electrical energy was about 10% efficient at an operating temperature of about 3,500 F.

The cesium cell is based on the

Edison effect: electrons boil out of a hot plate and collect on an adjacent cold plate. Cesium vapor in the cell aids direct conversion three ways: (1) it speeds rate at which electrons boil out of the emitter; (2) it reduces energy loss at the cold surface; (3) it ionizes, forming plasma, which greatly aids passage of the electrons.

These reactor tests are the first step in proving the practicality of nuclear-thermionic systems for both land and space applications. General Atomic says it appears the efficiency of the cesium cell can be further boosted when its dimensions are optimized and when its capability for higher temperature operation is realized. Too, rejected heat from the cesium cell can be utilized in lower-temperature semiconductor devices, increasing over-all thermal efficiency.

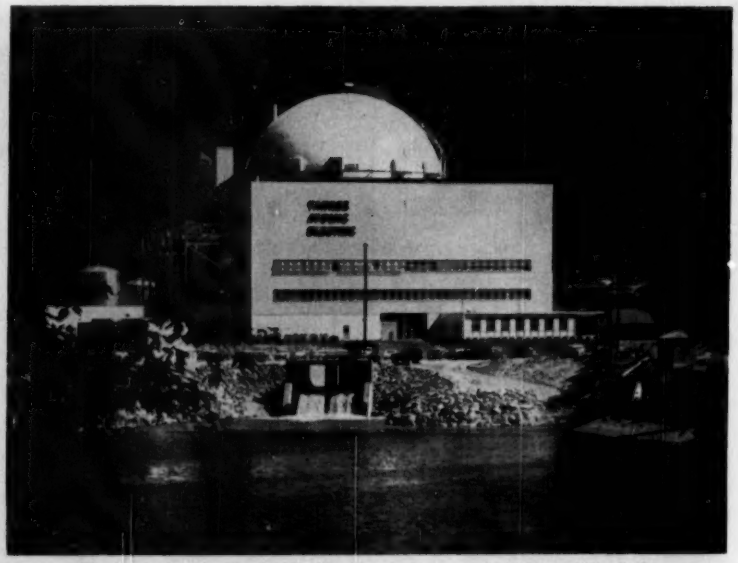
It appears, however, that these direct conversion devices will have to achieve dramatic increases in efficiency before they can compete with standard land-based nuclear power-generating plants that can now achieve about 35% over-all efficiency. First application of the thermionic devices will probably come in space vehicles where weight is a prime factor.

Oyster Growers Demand Stiffer Pollution Laws

Pacific Coast Oyster Growers Association, holding its annual convention in Tacoma, Wash., has adopted a resolution urging more rigid state controls on the pulp and paper industry. The group's special target: sulfite pulp mills that dump waste liquor into rivers and streams.

The resolution recommends that 85% of sulfite waste liquor be disposed of by means other than discharge into streams, and that no more than 3 ppm. of sulfite liquor be allowed outside certain authorized dispersal areas. These standards are more strict than regulations now under consideration by the state's Pollution Control Commission.

CPI Briefs



Yankee atomic plant will begin producing electricity this fall.

Yankee Atomic Electric Co. took a big stride at its atomic power plant at Rowe, Mass., in August, when the facility's nuclear reactor went critical. The move followed two weeks spent in placing the reactor's 76 uranium oxide fuel assemblies in position. Yankee Atomic's new plant, pictured above, is owned jointly by ten New England utilities companies; it is the first nuclear-powered electric generating station in New England. Rated at 136 megawatts, the facility is due to start producing electricity this fall. Westinghouse Electric Corp. designed and developed the reactor, which will heat high-pressure water to 529 F. during operation. Engineering design for the plant was handled jointly by Westinghouse and Stone & Webster Engineering Corp.

Texaco Inc. recently placed a new cumene unit on stream at the company's Eagle Point Plant in Westville, N. J. Having a capacity of approximately 70 million lb./yr., the facility is described as one of the largest plants of its type in the world. It has been designed to produce cumene of very high purity, so that the product will be well suited for manufacture of quality phenol and phenolic plastics. Texaco makes its cumene by using benzene, propylene as raw materials.

Houston Chemical Corp. has awarded a $10-million construction contract for plants to make tetraethyl lead, tetramethyl lead at Beaumont, Tex. The plants will be built by Singmaster & Breyer, of New York; they are expected to go on stream by September, 1961. The move will make Houston Chemical the third U.S. producer of these gasoline additives. (Other two: Ethyl Corp., Du Pont.)

Phillips Chemical Co. is adding facilities at its plant near Houston to raise production of the firm's Marlex plastics by about 33%. New production level will be 100 million lb./yr. The plastics include high-density polyethylenes, ethylene copolymers and tailored resins.

CPI BRIEFS

(continued on page 136)

CARBON-BLACK MASTERBATCH TAKES OFF

Production has tripled in the past three years. Behind the surge are process and product benefits that promise to grow even larger.

FRANCES ARNE
Associate Editor

Carbon black masterbatch jumped from a low of 7.2% of total SBR production in 1957 to 16.4% in 1959 and is expected to exceed 20% on 1960. By 1963, it promises to plateau at about the 25% level.

The rapid rise has been generated by an unbeatable combination of forces:

Customer Convenience—Mixing carbon black and rubber in the polymerization plant relieves the rubber goods customers, e.g., rubber compounders and fabricators, of the messy jobs of storing, handling and mixing carbon black.

End-Product Improvements—New masterbatching techniques, commercialized by seven SBR producers since 1957 at a total new plant investment of $7.5 million, turn out products 10 to 15% more wear resistant than their conventional predecessors, i.e., products made from rubber and carbon black Banbury-mixed in the fabricators' plants.

Lower Costs — Masterbatches made in the polymer producer's plant consume considerably less power and time than those made by Banbury-mixing carbon black into dry rubber in the compounder's plant. For their masterbatch rubber, manufacturers are getting about the same price that customers would have to pay for separate purchases of carbon black and rubber.

Background grumbling among rubber manufacturers has it that profit margins on masterbatch are narrower than those on unpigmented SBR, indicating some disproportion of masterbatch benefits. It is anticipated that this trend toward lower pricing of the carbon black masterbatches compared with the clear rubbers will be reversed as the technological advantages are further advanced over CB-SBR compounds mixed in the rubber fabricators' plants.

In any case, no reversal of the trend to masterbatching at the polymerization plant is likely. For one thing, the new masterbatching techniques offer opportunity for even further product improvements. By better dispersion of carbon black in particle-sizes suitable for conventional Banbury mixing, they have already made improvements. But, unlike older methods, they can accommodate even finer particle sizes and lower structures. The finer the particle size and the lower the structure of the carbon black, the stronger and less noisy (in tires) the rubber. Carbon black manufacturers are already at work tailoring products to exploit these new possibilities.

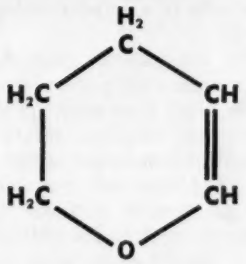
And masterbatching appears to be only the advance wave of a tidal movement from the consumer's plant to that of the rubber supplier of initial compounding operations. Here, buyers are convinced, the operations can be performed more cheaply and under superior conditions of control.

In fact, with new masterbatching techniques barely established commercially, rubber suppliers are well along in the development of

NEW DEVELOPMENT CHEMICALS

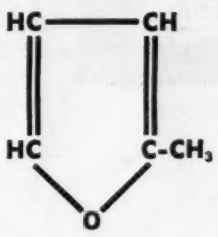
from The Quaker Oats Company

QO® Dihydropyran



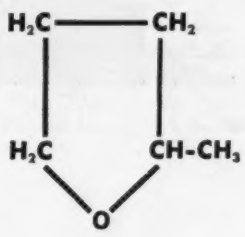
QO Dihydropyran is a colorless, mobile liquid of ether-like odor. Alcohols add readily to the double bond in the presence of acids; thus addition of methanol forms 2-methoxytetrahydropyran, an acetal from which the alcohol may be readily regenerated by hydrolysis. Here, then, is a method of protecting alcohol groups during reactions. Bulletin 137 describes many more reactions, and gives references.

QO® Methylfuran



QO Methylfuran is a cyclic dienic ether which merits attention as a chemical intermediate. It is a colorless, mobile liquid of ether-like odor which is infinitely miscible with most organic solvents. Write for a copy of Bulletin 135.

QO® Methyltetrahydrofuran



QO Methyltetrahydrofuran is a cyclic ether useful in organic synthesis, and may also have value as a reaction solvent. It is a colorless, mobile liquid of ether-like odor. In water it has the property of inverse solubility—that is, solubility increases with a decrease in temperature. Request Bulletin 136.

Physical Properties

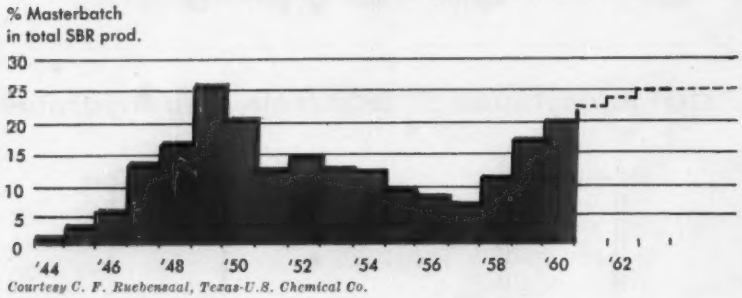
BOILING POINT, °C. (760mm) Pure Compound	84.3	64.0	80.2
FREEZING POINT, °C.	−70	−88.68	−136
SPECIFIC GRAVITY, 20/4°C	0.927	0.913	0.854
REFRACTIVE INDEX, n 25/D	1.4180	1.4305	1.4025
FLASH POINT, °F (Tag closed cup)	0	−16	12
SOLUBILITY g./100g. H_2O	1.6 (25°C)	0.3 (20°C)	15.1 (20°C)
g. H_2O/100g. chemical	0.5 (25°C)	0.25 (20°C)	5.3 (20°C)
WATER AZEOTROPE % water	9.8 (b. 71-2°C)	—	—
VAPOR PRESSURE, mm. of Hg			
at 0°	34.9	59.0	37.8
10	57.0	95.2	64.5
20	—	142	102
30	148.0	225	165
40	—	336	248
50	302.0	480	366
60	—	688	536
70	600.00	—	—

All of the chemicals are available in cans and 55 gallon drums.
For samples, write on your letterhead stating which product you wish.

The Quaker Oats Company
CHEMICALS DIVISION

335L The Merchandise Mart, **Chicago 54, Illinois**
Room 535L, 120 Wall Street, **New York 5, New York**
Room 435L, 48 S.E. Hawthorne Blvd., **Portland 14, Oregon**

Black rubber to level off at new high



Courtesy C. F. Ruebensaal, Texas-U.S. Chemical Co.

replacements. One good possibility: combination of master-batching—of other compounding ingredients as well as carbon black—and drying of crumb rubber into one operation. Currently, masterbatching takes place while polymer is still in the latex stage; conventional drying is by passage through hot-air tunnels. Two new methods, already boasting installations, for flash-drying rubber by working it mechanically offer possibilities for simultaneous compounding.

▶**Endorsement Widespread**—Goodrich-Gulf, Texas-U. S. Chemical, Copolymer Rubber & Chemical, General Tire & Rubber, Phillips Chemical, Shell Chemical and United Carbon have all installed commercial units based on new masterbatching technology in the past three years; and Firestone has one under construction at Lake Charles, La., to start up early in 1961. Production just about tripled from 1957 to 1959, going from 90,897 long tons to 258,000; about 325,000 long tons are expected this year.

The new technology, pioneered by Columbian Carbon Co., harnesses mechanical mixing to achieve superior dispersion of black in rubber latex. Superior dispersion allows fuller utilization of the black's reinforcing potential.

▶**Latex Masterbatch Out**—Masterbatching, by dispersion of black in rubber at the latex stage, had a day in the sun once before in the early '50s. But the old process, developed by the government and called the carbex process depended on the use of chemical dispersants. Subsequent improvements in SBR manufacture and compounding, e.g., the use of finer blacks for greater rubber strength and the large-scale production of oil-extended, high-Mooney SBR rubbers, increased the amount of dispersant needed to do the job. Larger quantities of dispersant weakened the carbon-rubber bond. Resulting rubbers were 5-10% weaker than those turned out via Banbury mixing of rubber and black in the compounder's plant. Operational economies of carbex masterbatching could not counterbalance these end-product penalties.

▶**Mechanical Masterbatching In**—New masterbatching methods use specially designed machinery that produces a high degree of shear to disintegrate agglomerates of black particules but no grinding action to expose dry black on the grinding surface. This dispersion is kept suspended by violent agitation in dispersant-free water. When the unprotected (free of chemical dispersing agents) carbon black is turbulently blended into latex, it acts as a creaming agent so that only a coagulating agent is needed to effect a uniform black-rubber crumb that may be subsequently dewatered and dried in a conventional manner.

▶**Tailored Carbon Blacks**—Carbon black of the finest particle sizes blendable on compounders' Banburys is 20-millimicron ISAF. But 17-millimicron SAF, which formerly lent itself only to specialty use, can be successfully dispersed in SBR by the new mechanical masterbatching technique. With use of finer black, strength and abrasion resistance of SBR rubber can be even further increased. And it will contribute to a quieter-riding tire as well.

New mechanical methods can also accommodate a lower structure carbon black than previous mixing techniques. Structure refers to arrangement in space of carbon black units and so-called low structure imparts greater stiffness to the rubber, increasing its resistance to stress, lowering the noise level of rubber in tire use. This effect of low-structured carbon blacks has been recognized for some time but, most opportunely, carbon black manufacturers have recently learned to control structure. Both Cabot and Columbian Carbon have produced low-structure material and have already shipped up to hopper-car lots to rubber companies for testing.

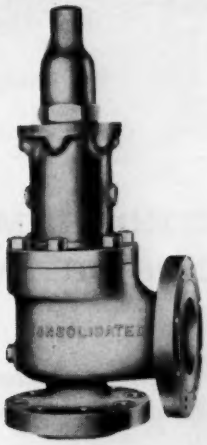
▶**The Next Step**—At least two new ways to combine initial compounding steps with rubber drying are under test. Goodrich-Gulf recently started commercial operation of an extruder that works rubber to a heat at which it flashes dry under vacuum (*Chem. Eng.*, Aug. 8, 1960, p. 62). Compounding in the extruder-dryer is under investigation.

Other mechanical drying methods are based on modifications of the Banbury mixer. One such installation, for drying, has already been made by General Tire & Rubber. Four others are on order, two of which will attempt simultaneous compounding and drying.

▶**Transport Savings**—Additional upcoming masterbatch benefits: increased ease of shipping, storing and handling. Because it is denser and occupies less volume than either carbon black or unpigmented rubber, masterbatch already has the advantage over them. Now attempts to pelletize it—which could not be made on unpigmented rubber because of its cold-flow characteristics—may give it bulk handling advantages.

top

CONSOLIDATED SAFETY RELIEF VALVES have a special "O" Ring Seat Seal that stops leakage completely



Consolidated Safety Relief Valves are available in both Standard and Balanced Bellows design for extreme corrosive applications.

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The Seal is a resilient ring set in the valve disc. It maintains no-leak tightness by contact with a specially curved seating surface on the valve nozzle, yet does not carry the seat load imposed by the valve spring.

Tightness is maintained at operating pressures far closer to set pressure than with metal-to-metal seats alone. Tight closure is as efficient after "simmer" as on normal blowdown. Piping strains are absorbed far better by the resilient seal than all-metal seating. If the tough seal is ruined by entrained abrasives, replacement is easy. Seals are available in materials that resist corrosive fluids. Maintenance costs are greatly reduced.

Standard Consolidated Safety Relief Valves have an eductor tube that removes pressure from the closed bonnet. Only the spring controls valve action. You get guaranteed capacity ratings and highest dependability—absolute protection for personnel and equipment. Additionally, there is the economy of converting the Standard valve to the Balanced Bellows type in your own shop. Get complete details. Write for Bulletin 1940.

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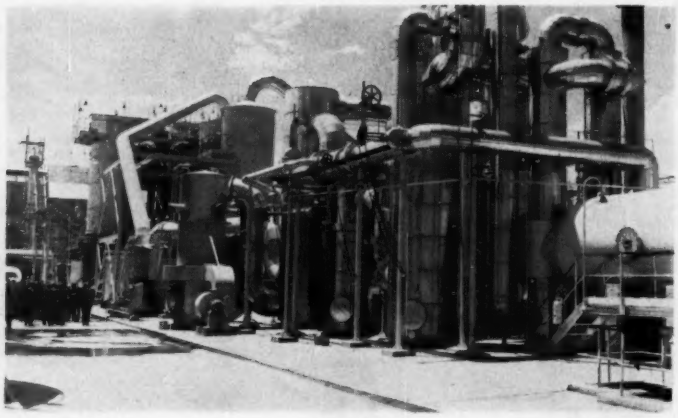


ADD PETROCHEMICALS TO AUSTRALIA'S CHEMICAL BOOM

American-backed, petrochemical complex now highlights continent's economic growth.

World War II was a blessing in disguise to the Australian chemical industry.

With her traditional supply lines cut, Australia was forced to expand facilities from production of fertilizers and explosives to a wide range of inorganics, petroleum and petrochemicals.

This postwar growth is rapidly snowballing into a boom that has already attracted a $290-million investment in petroleum alone, with $90 million worth of additional petrochemical facilities presently under construction.

About 25% of Australian foreign investment is American and, of the four top chemical companies, two, Union Carbide Australia Ltd. and Monsanto Chemicals (Australia) Ltd., are American subsidiaries.

Petrochemicals currently constitute the fastest-growing and most recent industry in the Australian chemical field.

The industry as a whole can be divided roughly into two groups, the older "pre-petrochemical", and the fast-growing petrochemical.

Among companies in the older group, by far the largest is Imperial Chemical Industries of Australia and New Zealand, Ltd., which is associated with Imperial Chemical Industries of the United Kingdom. Considering its assets in both organic and inorganic productions, Imperial of Australia has a paid capital of more than $40 million.

Other companies of importance, excluding the strictly pharmaceutical companies, are Colonial Sugar Refining Chemicals Proprietary Ltd. (CSRC), previously-mentioned Monsanto and Union Carbide, and Reichhold Chemical Industries (Australia) Ltd., allied with the American company.

These companies comprise the major portion of the pre-petrochemical structure of the industry, covering a huge segment from oleum to synthetic resins.

The tremendous influx of American capital in the petrochemical industry has produced an intricate meshing of affiliations that is perhaps best illustrated by the Altona complex, a group of plants arising around the refinery of the Standard-Vacuum Refining Co. near Melbourne.

This refinery will pipe distillate to the petrochemical plant of its affiliate, the Vacuum Oil Co., which will produce basic chemicals ethylene and butadiene. At least four other companies will make use of these chemicals:

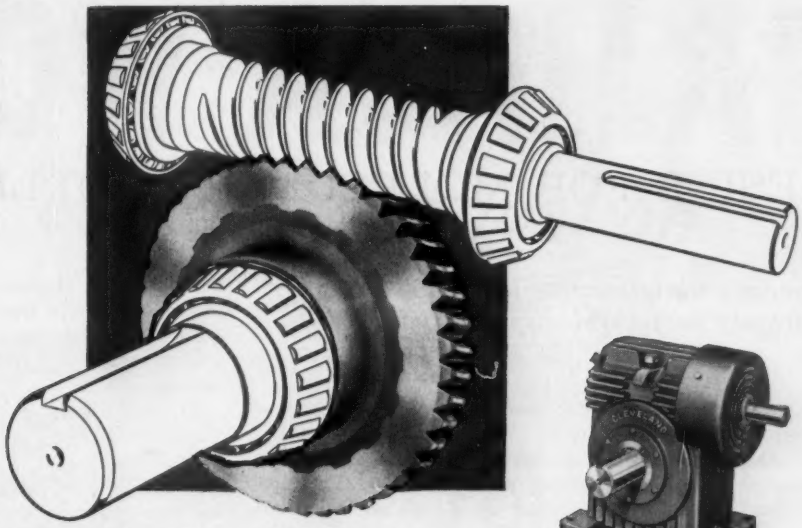
- C. S. R. Chemicals-Dow Pty. Ltd. (CSRC and Dow Chemical International) will make styrene from ethylene, utilizing benzene from the coke ovens of Australia's steel industry.
- B. F. Goodrich-C. S. R. Chemicals Ltd. (CSRC and B. F. Goodrich Chemical) will make polyvinyl chloride from ethylene.
- Australian Synthetic Rubber Pty. Ltd. (Vacuum Oil Co.) will make SBR rubber from butadiene and styrene.
- Union Carbide Australia Ltd (Union Carbide Corp. of America and Australian stockholders) will make polyethylene.

Like CSRC, Imperial is also vitally tied up in petrochemicals. In the neighboring state of New South Wales, Imperial is planning a plant to polymerize ethylene, an economic improvement over its present method of making the polymer from ethyl alcohol. The ethylene will come from the plant of Shell Chemical (Australia) Ltd., which is adjacent to the Shell refinery at Clyde, New South Wales.

In another petrochemical move, Monsanto, in alliance with the Petroleum and Chemical Corp. (Australia) Ltd., will produce styrene monomer.

All this production is possible mainly because of the rapidly expanding consumption of Australia's 10 million people. The population continues to increase, attracting 100,000 immigrants a year, is expected to reach 15 million by 1980.

With well over a million of Australia's population already employed in industry, Australian government officials are still on the road soliciting industry.



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...New Higher Horsepower Cleveland Speed Reducers feature centrifugally cast bronze gears

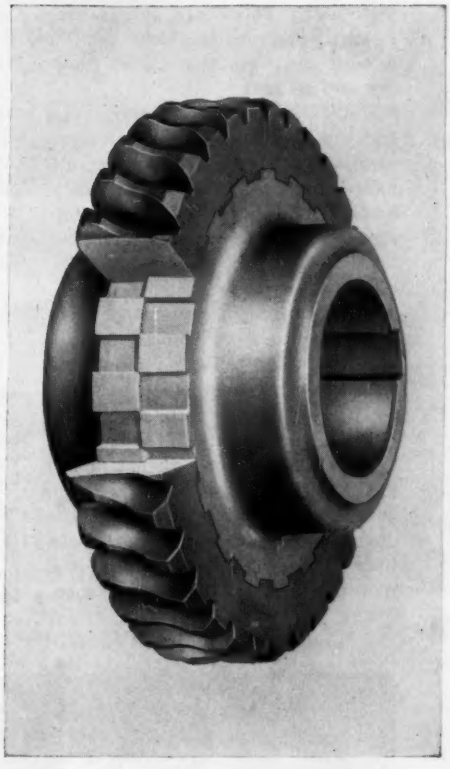
Providing higher input horsepower and output torque ratings, *New* Cleveland Speed Reducers now give industry dependable speed reduction at savings of 50% or more on per horsepower cost—without increasing size of the units.

Playing an important role in helping achieve these improved new ratings are Cleveland's centrifugally cast bronze gear rims of a high copper-tin-nickel alloy. When properly cast, this material provides highest strength compatible with requirements that it be free from abrasive crystalline components. Yet it's yielding enough to avoid excessive loading stress localization, while affording a low coefficient of friction against hardened steel—providing increased resistance to wear and fatigue pitting.

These rugged bronze rims are cast integrally with their supporting cast iron hubs (see photo at right). Checkered hub circumference holds the rim securely in position, making the two members independent of actual surface bond.

Also, another plus value of the New Cleveland Reducers is their especially large gear shaft diameters—which provide greatly increased overhung load carrying capacity.

For complete facts on this New Cleveland Speed Reducer Line, consult your local Cleveland Representative. Or, write us direct for free Bulletin No. 405—it gives *complete* engineering information for designers and engineers.



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NEW RESINS FOR MOLECULAR COMPLEXING

Two polymers with interesting functional groups gain importance in several disparate industries.

Soon, these two Devlex resins will literally go to your head—if you use hair tonics or shampoos, drink wine or beer.

Recently introduced by Dow Chemical, the products are white, free-flowing powders that offer a wide range of applications in cosmetic, wax, polish and ink formulations, leather finishing, textile dyeing and stripping, tablet binding and coating.

▶**Modify Without Change**—As functional polymers, they are used in the syntheses of many organic and inorganic complexes: they modify solubility, volatility, stability and, on occasion, the odor and taste of complexed molecules without changing their chemical nature.

Film-forming properties of Devlex resins are most effective on proteinaceous and cellulosic substrates such as cotton, wool paper, hair and leather.

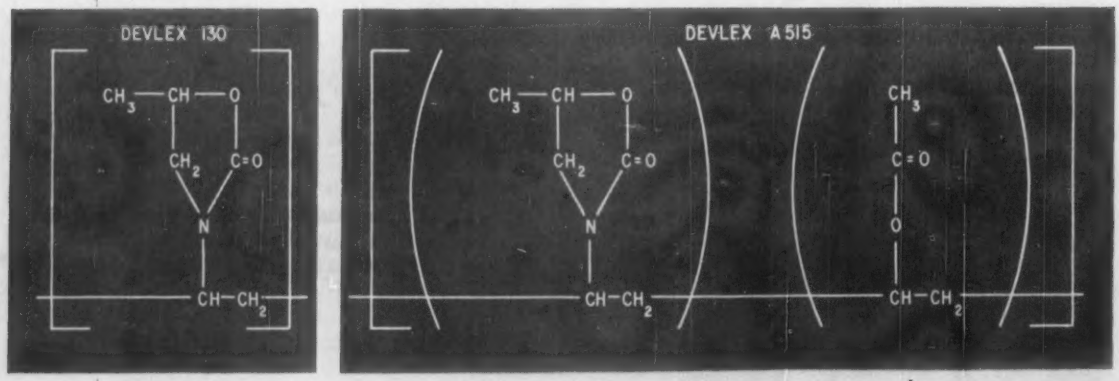
When cast on these substrates, Devlex A515 films display more flexibility because of their affinity for these surfaces and the plasticizing effect of bound water. In hair grooming preparations, the new products increase body sheen, offer better control after shampooing and protect against buildup of static electricity. Potential applications include the clarification and stabilization of beer and wine and control of many biologically active compounds. Special research grades of Devlex resins are finding additional applications in the food and drug industries.

▶**Resembles Protein**—Chemically poly - N - vinyl-5-methyl-2-oxazolidinone, Devlex 130 has properties suggestive of the albumin group of proteins that are readily soluble in pure water but precipitated out by neutral salts. It has the additional advantages of purity and structural definition of a high-quality synthetic organic chemical. Available in semicommercial quantities, Devlex 130 has been designed for molecular complexing and film applications.

The other resin, Devlex A515, is a copolymer of N-vinyl-5-methyl-2-oxazolidinone and vinyl acetate, combined in equal weight ratios. In addition to the molecular complexing and film-forming properties of Devlex 130, it also provides organic solubility.

Mixtures of chlorinated solvents such as methylene chloride with another compatible solvent cause a marked synergistic increase in the solubility of Dexlex A515. This product yields hard, clear films that may easily be removed from substrates by warm water, with or without soaps or detergents.—**The Dow Chemical Co., Midland, Mich.** 60A

	Devlex 130	Devlex A515
Average molecular weight	165,000	.....
Melting point	250 C	between 125–135 C
Bulk density, lb./cu. ft.	30.5	31.5
Viscosity index	31.8	20
Heavy metals (Cu, Pb, Zn), ppm.	3	8
Ash, %	0.03	0.014
Unsaturation, %	0.46	0.47
Moisture, %	1	.....
Nitrogen, %	.....	5.48
Heat of combustion, Btu./lb.	10,350	.....



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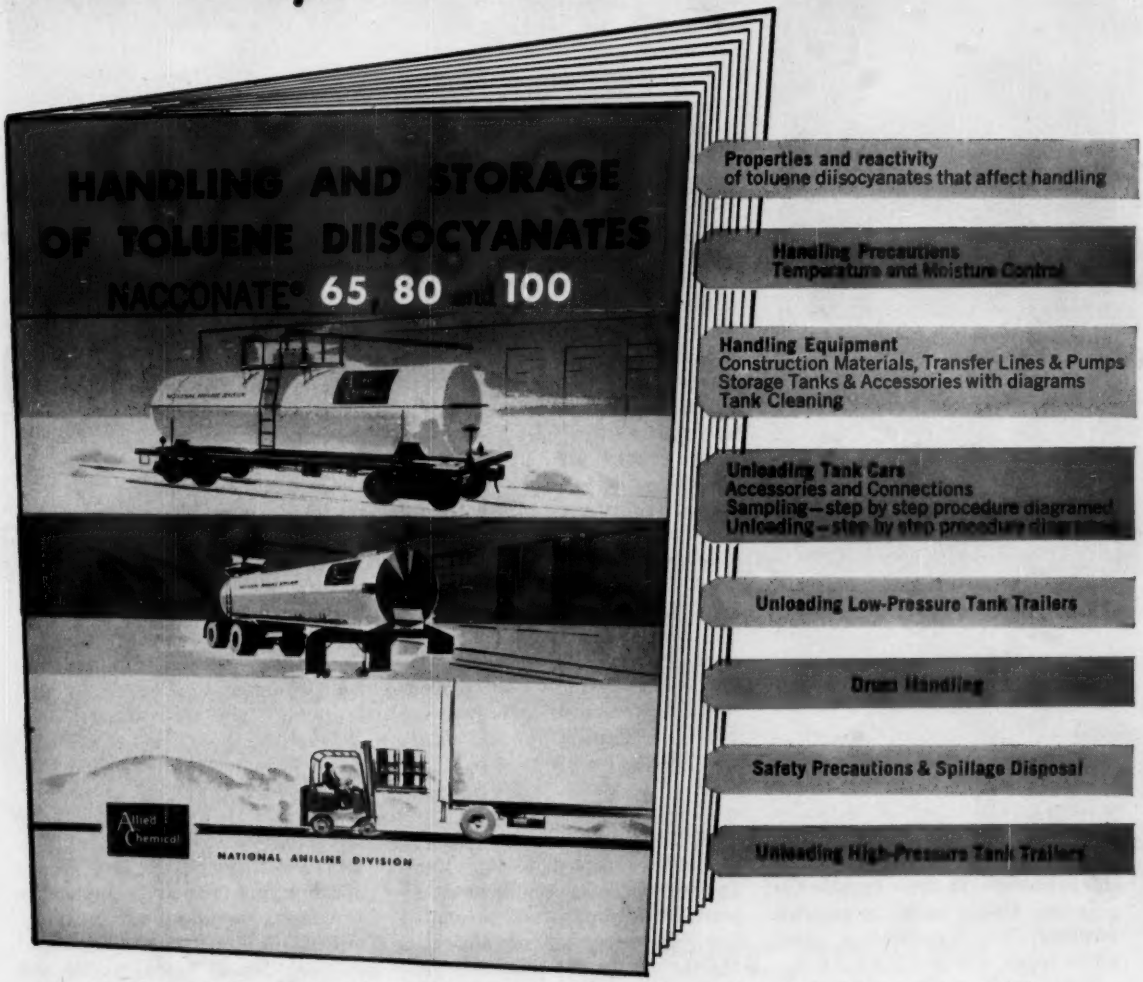

Properties and reactivity
of toluene diisocyanates that affect handling

Handling Precautions
Temperature and Moisture Control

Handling Equipment
Construction Materials, Transfer Lines & Pumps
Storage Tanks & Accessories with diagrams
Tank Cleaning

Unloading Tank Cars
Accessories and Connections
Sampling—step by step procedure diagramed
Unloading—step by step procedure diagramed

Unloading Low-Pressure Tank Trailers

Drum Handling

Safety Precautions & Spillage Disposal

Unloading High-Pressure Tank Trailers

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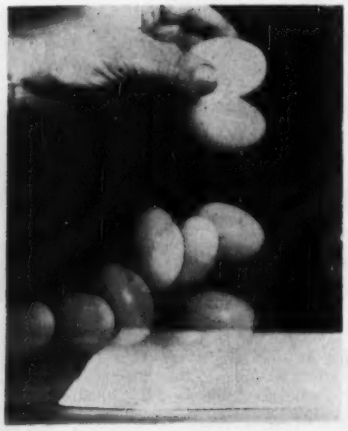
EXPANDED POLYSTYRENE THREATENS PAPER



It's a juggler's trick to toss eggs around without cracking them. But with Dyna-Foam, a special form of extruded polystyrene, even a child can get in the act.

What's immediately evident, aside from playing with eggs, is the great potential this material has in packaging and cushioning a variety of sensitive instruments, glass and other fragile objects.

Dyna-Foam starts as small polystyrene pellets. These are expanded under heat and pressure. During the process, gas expanding within the pellets makes them explode like popcorn. Unlike steam in popcorn, however, this produces a snow-white foam.

Cast as a sheet, Dyna-Foam looks and feels like rich, sparkling, pearlescent-white satin. When heated on both sides, it softens between 220 and 230 F. If these temperatures are exceeded, however, the foam collapses.

Declared nontoxic by the Food and Drug Administration and the U. S. Dept. of Agriculture, this product is nonabrasive, chemically inert and nondusting, so that it won't damage any object or material it is cushioning.

Like paper, Dyna-Foam can be run on all kinds of automatic equipment, lends itself readily to standard splitting, die cutting and sheeting. It can be glued and laminated to all paper products, aluminum foil and most thermoplastics, and can be heat sealed.

▶ **Other Uses**—Radio loudspeakers of Dyna-Foam are acoustically excellent and are unaffected by temperature or humidity. Considered a printer's dream, the product takes flexographic and silk-screen inks without treating, can be run on offset, rotogravure and letterpress printing machines. Gift wraps, disposable tablecloths, baby bottles, coffee cups and folding cartons have been made. Dyna-Foam is easily rendered fireproof and is now available in sheets, films, layflat tubing, pipe, board, solid rod and special shapes.

▶ **Insulates to −425 F.**—Bags or sheets have two advantages in food handling. The food will not only be kept warm, but there will be no seeping of greases and oils.

Wrapped around cold pipes, Dyna-Foam tape prevents sweating, and a 10-mil sheet provides insulation against heat as high as 212 F. and cold as low as −425 F. It can even be used as insulated wallpaper.

▶ **Dollar Potential**—Comparative cost studies have shown that where Dyna-Foam is a replacement for paper-based products, it is competitive as to price; ease of fabrication and the low density make this product available at about 0.5¢/sq. ft.

Company officials believe that Dyna-Foam can create a $500-million market in drug, food, insulating and cushioning products. In general, plastics have already replaced the equivalent of 365,000 tons of paper per year and the trend is increasing.—**Dyna-Foam Corp., Ellenville, New York.** 62A

Silicons

Solution reduces cleaning time in shell molding.

A new release agent that contains highly viscous silicone fluid dissolved in a petroleum solvent has been developed by General Electric. Called XS-4030, this clear and essentially colorless liquid can be used in the foundry industry for shell-molding and core-blowing where it reduces pattern cleanup time and enables longer runs without removing patterns from the machine.

As a release agent for the plastics industry, it may be used for compression, injection and layup molding and slip casting. In the rubber industry, XS-4030 acts as lubricant for surfaces of calender and embossing rolls and is a release agent in molding mechanical rubber goods.

The solution has a viscosity of approximately 5 centistokes, contains 5% silicone and has a density of 6.6 lb./gal. It may be applied by brushing, swabbing or spraying, either full strength or diluted.

This silicone is flammable and

Newsworthy Chemicals

Page number is also reader service code number

Two resins for molecular complexing..... 60A
Expanded polystyrene: paper's new competitor..... 62A
Silicone solution cuts cleaning time in shell molding..... 62B
Hexamethylenetetramine goes commercial..... 64A
Epoxy bonding agent welds nylon to metal..... 64B
Thimet phorate protects plants from pests..... 64C
Calcium silicate and asbestos fibers for insulation..... 64D
Amine-cured epoxy coating withstands exposures..... 64E

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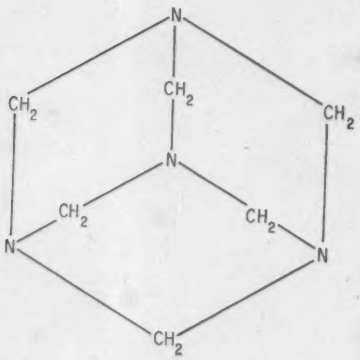
its vapors toxic, but no problems with shelf life are anticipated because XS-4030 is a true solution with no settling or separation.—**General Electric Co., Waterford, N. Y.** **62B**



Hexamethylenetetramine

Cross-linking agent is also used in petroleum and explosives industries.

Now sold in commercial quantities under the exotic name of Ucar hexa, this starlike material easily hydrolyzes in acid solution to formaldehyde and ammonia and, even in the absence of water, reacts as formaldehyde without developing that irritating odor characteristic of aqueous formaldehyde solutions.

It behaves as a weak, tertiary monobase, forming quaternary salts with many organic halogen compounds. Sometimes it is used in place of ammonium hydroxide as an alkaline catalyst in production of one-step phenol aldehyde resins. However, Ucar's main application is in curing novolac (phenol formaldehyde) resins.

▶ **Methylene Linkage**—When intimately mixed with a finely ground novolac resin and heated, it generates methylene groups that cross-link the novolac molecules to form an insoluble, infusible mass. Dry mixes of this sort are used for molding, fiber bonding, grinding wheels and foundry applications.

Incorporated in novolac varnishes, Ucar causes cross-linking when the dried resins are heated; such varnishes impregnate paper and fabrics for laminates and high-strength molding applications. It is also a valuable insolubilizing agent and hardener for proteins such as animal glue, casein and soya protein, in adhesive, coating and finishing uses.

Phenolic components of petroleum are complexed by Ucar and are easily recovered by solvent separation. During pickling operations, it inhibits corrosive action of acids on ferrous metals.

Other fields of application include use as starting material for production of cyclonite and other high explosives; as a rubber accelerator; as a component in solid-fuel tablets for military use where it burns with a smokeless, nonluminous flame.

Available either in powdered or crystalline form, Ucar is a compound of moderate oral toxicity. It should be stored in tightly closed containers to protect personnel from its vapors and keep it from caking through moisture absorption.—**Union Carbide Chemicals, New York.** **64A**

Adhesive

Chemical "welding" of nylon to metal is now possible.

Special epoxy bonding agent achieves an extremely tough, shock-resistant union between nylon and metal within a few hours. Welding is perhaps a misnomer since the entire operation occurs at room temperature.

The two-step process of welding is expected to find widespread use in such applications as the bonding of nylon gears to metal shafts or the securing of threaded screws or rods in nylon-and-metal assemblies. In the past, the self-lubricating qualities of molded nylon required a complicated mechanical interlock arrangement to prevent slippage.

Two materials are used: epoxy paste that chemically unites with the metal surface; and a separate solvent solution that is applied to the nylon piece softening the surface and allowing the nylon molecule to blend with the epoxy bonding as it hardens.

Nylon treating agent, a single-component material designated as PA-749 and the two-component epoxy agent called PA-708 come in separate 1-lb. bottles. PA-708 can also be supplied in bulk.—**Plastic Associates, Laguna Beach, Calif.** **64B**

Briefs

Insecticide, Thimet phorate, absorbed primarily through plants' root system, is translocated to the foliage thus protecting the plant against insect attack. Long residual action is provided against aphids, thrips and mites on chrysanthemums, carnations, dahlias and other ornamental plants.—**American Cyanamid Co., New York.** **64C**

Thermal insulation that withstands heat up to 1,800 F. is provided by calcium silicate combined with asbestos fibers and other materials. Effective for fireproofing walls, partitions, piping and equipment in all types of plants, Calsilite-Hi keeps its strength when wet and resists most chemicals.—**The Ruberoid Co., New York.** **64D**

Amine-cured epoxy coating, known as Carboline Epoxy 188, withstands weathering, severe acid, alkaline and salt exposures. It retains flexibility, won't stress-crack, dries quickly and, in warm weather, additional coats can be applied after 2 hr.—**Carboline Co., St. Louis, Mo.** **64E**

For More Information
about any item in this department, circle its code number on the
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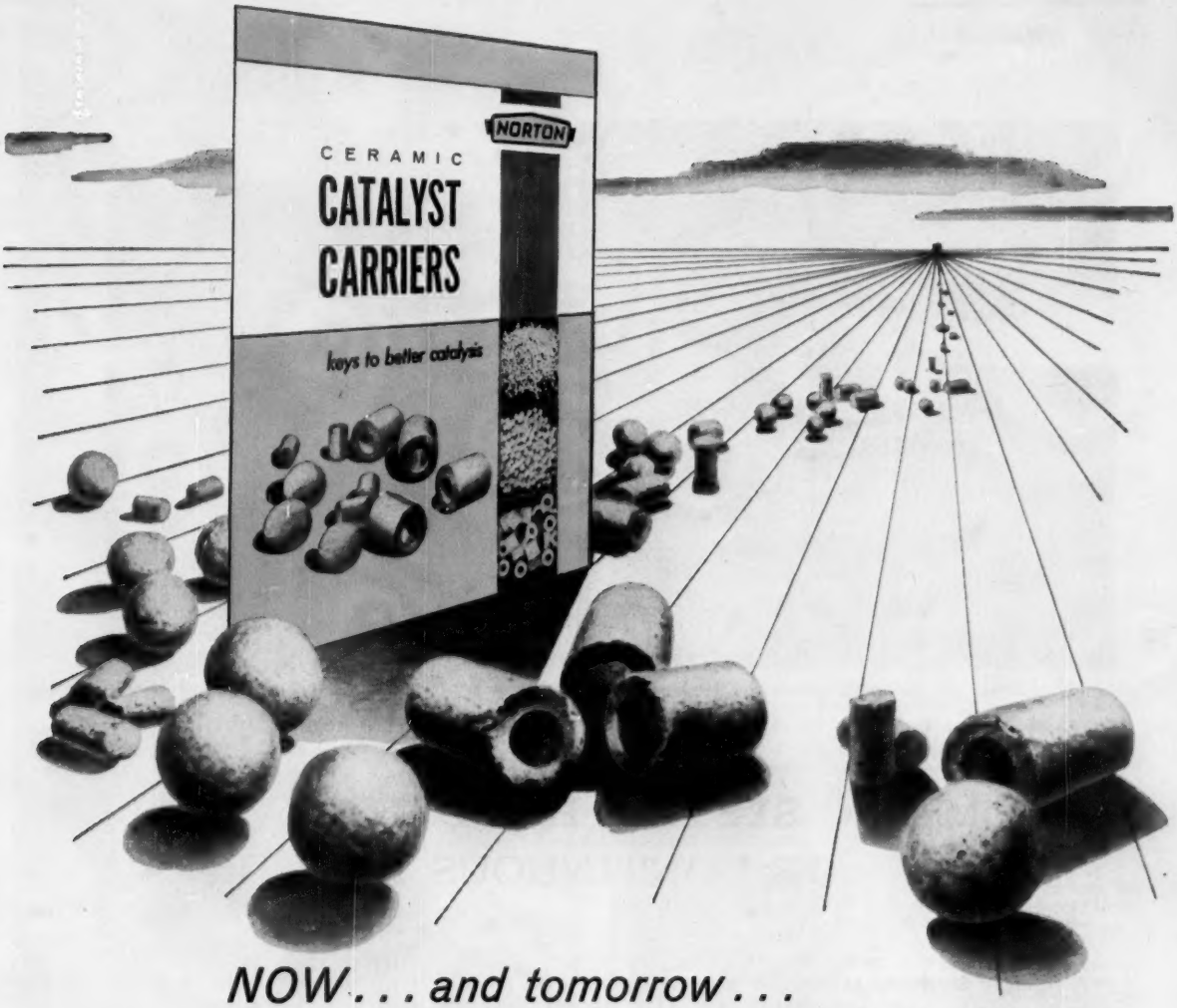
(Page 155)



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Today, probably the most widely-used NORTON Carrier is alumina . . . in ring, sphere, and pellet form and as granules and powder. However, as new feedstocks are developed, and more demanding physical, chemical, and thermal conditions are encountered, new NORTON Carriers will be ready to meet catalysis specifications. For example, various materials are now available in experimental quantities as spheres, rings and pellets . . . in alumina, magnesia-alumina spinel, fused magnesium oxide, silica, zircon, zirconia and silicon carbide. These NORTON developments offer porosities ranging from 4% to 65%; surface areas from less than 1 to 70m²/gram (BET method).

Also readily available is the technical assistance of the Norton Man. Through him, chemical engineers can draw upon the wealth of research and engineering data compiled over the years by the NORTON COMPANY. He is well qualified to help *you* meet catalyst carrier specifications exactly . . . efficiently . . . economically.

NORTON Carriers are described in detail in the Bulletin, "Keys to Better Catalysis". For your copy, or for technical assistance, write NORTON COMPANY, Refractories Division, 509 New Bond Street, Worcester 6, Massachusetts.

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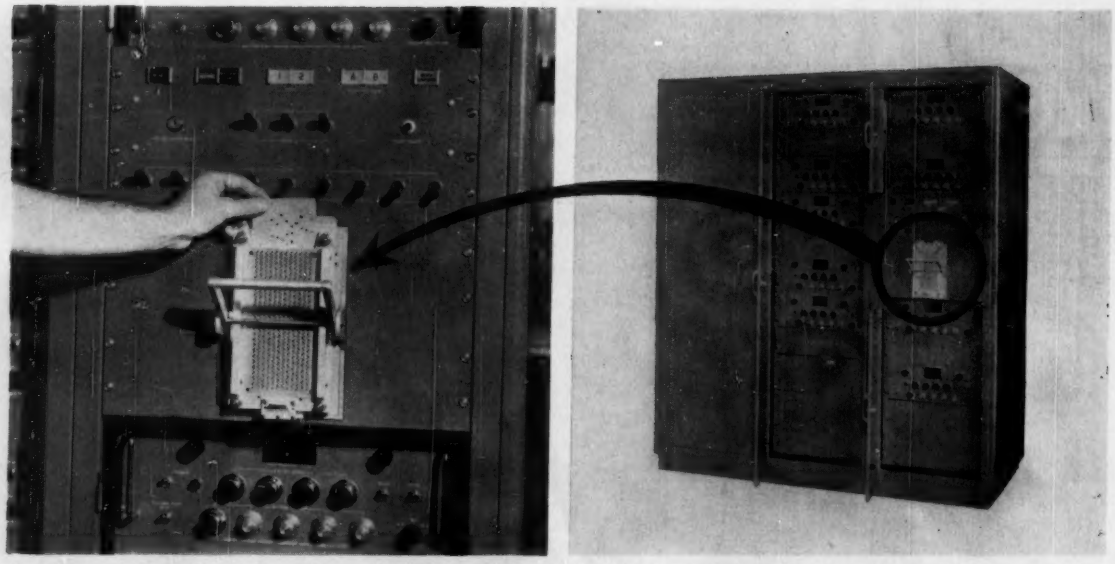


Simple punched card actuates automatic blending system that will mix nine ingredients and record their quantities.

AUTOMATIC SYSTEM HANDLES BATCH OR CONTINUOUS BLENDING

A recently developed automatic system quietly and accurately speeds batch and continuous blending of up to nine streams by delivering just the right proportions of liquids to a master blending tank.

Two main components comprise the system. Turbine flowmeters in each liquid line provide flow information for the central control unit, which indicates, counts and records while directing the operation.

Instructions to the controller may be introduced either manually or by a coded IBM punch card as shown above. The process is performed automatically and continuously as long as blending components are available in sufficient quantity.

▶ **Extreme Accuracy**—Key to flow measurement in the system is the Pottermeter turbine flowmeter. Claimed to measure the rate of flowing liquids with an accuracy of ± 0.1%, the meter has only one moving part, a turbine-type rotor.

Mounted without thrust bearings, the rotor positions itself hydraulically, spins freely. Rotor friction is virtually eliminated, thus enhancing accuracy and reducing wear. The meter can be introduced into the liquid line in any position, will perform linearly over a wide flow range.

A permanent magnet is built into the hub of the rotor as part of the flow-sensing system. As the flowing liquid spins the rotor, the magnet produces an electrical pulse in a coil mounted externally in the housing. Pulses are transmitted to the controller in any remote location.

▶ **Master Control**—Flow information is accumulated by the main control unit, which compares flowing quantities of each ingredient with its programmed amount, shuts off flows when right amount has been added.

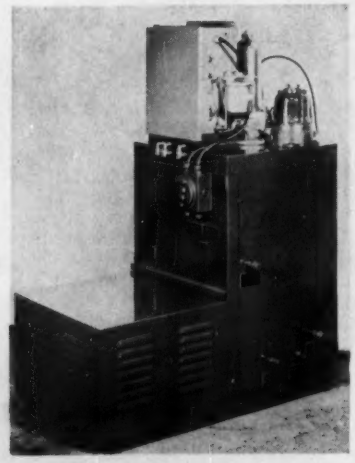
Using modular units as building blocks, the controller contains 3,000 semiconductor diodes, 2,000 transistors. Lights on the panel face keep the operator informed at all times of the status of the operation.

Let any irregularity occur, such as the shortage of one of the blend materials, and the whole operation will be automatically suspended until the condition has been corrected, whereupon blending will resume exactly where it stopped.

For batch blending, when all components of the blend have been introduced into the blending tank, the controller allows time for all pipes and headers to drain before switching flows to a second blending tank for another batch.

A Potter automatic batch system in Boston blends ice cream mix for H. P. Hood & Sons. Hood reports

that the Potter system saved so much plant space that a proposed plant expansion was postponed.—**Potter Aeronautical Corp., Union, N. J.** 66A



Viscosity monitor

Analyzer measures and controls viscosity of flowing fluids.

A new integrated viscosity-controlling package monitors in-line viscosities by removing fluid from pressurized line, measuring its viscosity and returning it to the line. The unit works to 550 F. and 150 psi.

Called the Stream Analyzer, it is equipped with two gear-pumps that produce a steady flow of 1 gpm. through the 0.3-gal. sampling chamber, which is insulated and surrounded with a copper coil so it can be heated with the same fluid that is in the main-line tracings. Motor and switches are explosion proof.—**Brookfield Engineering Laboratories, Inc., Stoughton, Mass.** 68A

Precision tank gage

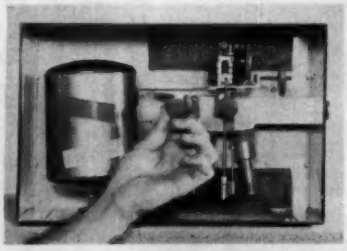
Purge-bubbler principle gives accurate tank readings.

Chemicals, high-temperature liquids, volatile or pressurized liquids —whatever the tank contents, they can be satisfactorily gaged with the new Exactel Servomanometers, according to the manufacturer.

Operating on the purge-bubbler principle, the gage converts the pressure at the bubbler exhaust in the bottom of the tank into inches of mercury. Readout is in appropriate direct units, such as bbl., cu. ft., ft. of depth or gal., to five significant figures.

Since measurement is basically a weighing process, it is not subject to temperature variation in the measured material. Unit automatically compensates for ambient temperature variations in the region of the manometer, which may be located remotely. Manometer, 32-in. range, is glass or, for pressure operation, stainless steel.

The only materials contacting the measured fluid are the bubbler pipe and the impulse gas, which is usually dry nitrogen. Instrument is said to have operated continuously for over a year without maintenance, reporting data for billing purposes with an accuracy of one part in 10,000.—**Steimle Co., Palo Alto, Calif.** 68B



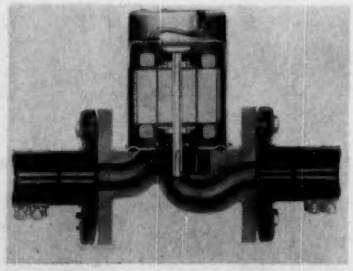
Air-density monitor

Gas detector uses mechanical balance principle for alarm.

A new safety instrument, the Detectogas Air Density Monitor, is said to be the first gas detector to use a mechanical balance principle, which enables the unit to operate round the clock without attention and without power.

In operation, it compares the displacement buoyancy of a float in the surrounding air with a set standard density, usually that of normal air. Automatically compensated for changes in temperatures, humidity and pressure, the instrument can detect a change in air density as small as 1.2% when caused by heavier or lighter-than-air gases or vapors.

Unit cost of $800 is said to be about ⅓ that of existing automatic gas detection equipment.—**Detectogas Instruments, Inc., Houston, Tex.** 68C



Seal-less water pump

Leakproof unit for heat exchanger circulation.

Designed especially for use in closed clean-water systems, a new seal-less water-circulating pump is equipped with rubber flanges for quiet operation. Installed in any position, it can handle up to 90,000 Btu./hr. in zones with a 20-deg. temperature drop.

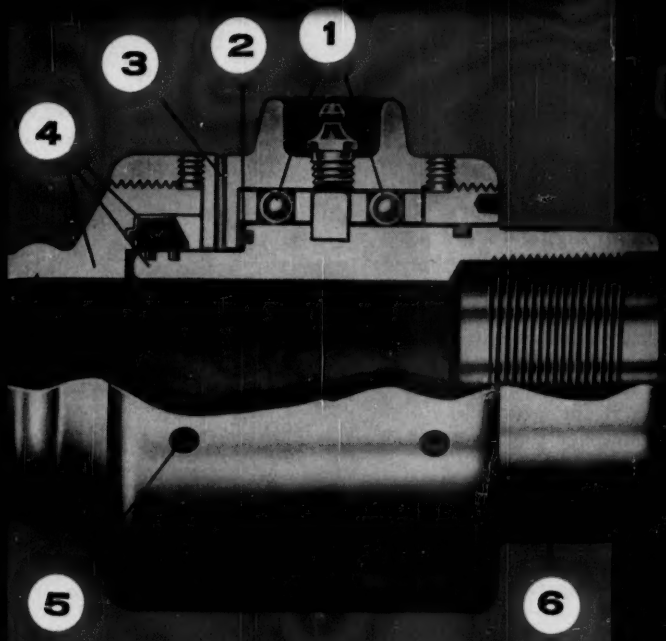
Suitable for pressures to 30 psi. and temperatures to 220 F., Model 400A circulates up to 12 gpm., has no stuffing box or seal. In typical canned construction, pumped fluid acts as bearing lubricant and motor coolant. Pump operates on 115 or 220 v.—**Fostoria Corp., Fostoria, Ohio.** 68D

Equipment Cont'd on Page 70

For More Information

about any item in this department, circle its code number on the **Reader Service postcard**

(Page 155)



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4. Only Wettable Parts and Packing Contact Fluid
5. Simple Set Screws Allow Joint to Break Like a Union . . Bearings and Other Parts Not Disturbed
6. Thread, Weld, Flanged End Connections Available

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US TYPE SWIVEL JOINTS

..handle corrosive chemicals

..stop grease contamination of fluids

..are repaired on location with simple tools

..can be welded into the line

Continental-Emsco US Type swivel joints are designed *exclusively* for the chemical industry. Fluid contacts metal and packing only, so wettable parts of corrosion resisting stainless steel (or other alloys) can handle all types of caustic products. Primary Teflon packing, *deformed* into grooves for a tight seal, and a secondary asbestos seal prevent grease from contaminating products. Packing chamber design is patented. It reduces bearing wear by preventing packing from pressing against bearings, and allows free swiveling regardless of internal pressure. Joints break like a union without unseating ball bearings and other parts. Joint can be welded into the line, eliminating costly flanges. Threaded and flanged ends are also available. Wide bearing spacing through use of solid bearing races insures accurate alignment and provides maximum bearing support for internal and external loadings. Races are separate and can be reversed to double their life. Repairs and adjustments are made on the spot, without special tools . . shop or factory equipment not required.

Save installation and maintenance costs by designing, building or replacing with Continental-Emsco swivel joints. There's a size and type to meet all your product handling problems. Let us bid on your next requirement.

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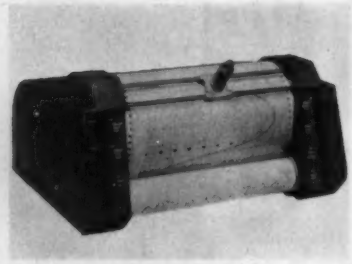


X-Y recorder

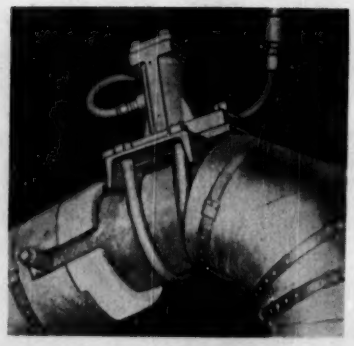
Unit converts, plots digital data for all three directional axes

A new high-speed recorder converts digital information regarding the relative variation of two functions into corresponding incremental motions of plotting paper and plotting pen. Relation to a third function is obtained by raising and lowering the recording pen to vary the shades of marked line.

Model 560-RX-Y plotter can accept data from all digital computers, can be driven by both punched paper tape and punched card data processors. It has excellent potential for monitoring industrial processes.

Incremental movement of the recording paper drum provides X-axis motion, movements of the ball-point recording pen provide Y axis. Z-axis modulation is accomplished with a solenoid that raises and lowers the pen.

Drum and pen increments are 0.01-in., positive or negative. Instrument can perform up to 200 incremental steps/sec. on X and Y axes. Unit cost: $3,300.—**California Computer Products, Inc., Downey, Calif.** 70A



Pneumatic vibrator

Timed piston impact keeps wet, moist material moving.

Are you plagued by moist materials that pack in pipes when high frequency vibrators are used? Your problem may be solved by a new pneumatic impacting vibrator that, according to the manufacturer, keeps such material moving through all types of piping arrangements.

Called the Navco BH-2 air vibrator, the new unit has a one-piece design that eliminates body assembly bolts, cuts maintenance downtime. Safe in hazardous atmospheres or under extreme moisture conditions, the BH-2 dislodges powdered coal, carbon black, ores and fly ash. It works on magnetic dusts.—**National Air Vibrator Co., Cleveland.** 70C

Here's a twist—they're putting oil back in the Gulf!

When plants located along the seacoast run out of tank farm space, they can simply build more tanks under the ocean, if tests on new flexible rubber containers are a success. A 50,000-gal prototype tank, shaped like an envelope so it won't buckle or crease when empty, is submerged more than 50 ft. in the Gulf of Mexico. A nylon net-like harness holds the tank to the bottom while a floating buoy marks its location and connects it to the surface through a 6-in. hose. If the experiment works, a series of such tanks may be used for secret Navy fueling depots, among other uses. The four poles are piles that were driven into the Gulf bed to secure the tank, which is lowered into place with a 10-story high crane. Reinforced by two-ply nylon, the tank measures 80 x 33 ft.—**United States Rubber Co., New York, N. Y.** 70B

Gas regulator

Velocity baffle, sensitive diaphragm give constant pressure.

A patented velocity baffle and a sensitive diaphragm are the keys to accuracy of a new zero regulator that holds constant outlet pressure to within 0.1 in. of water at all flow rates, according to the manufacturer.

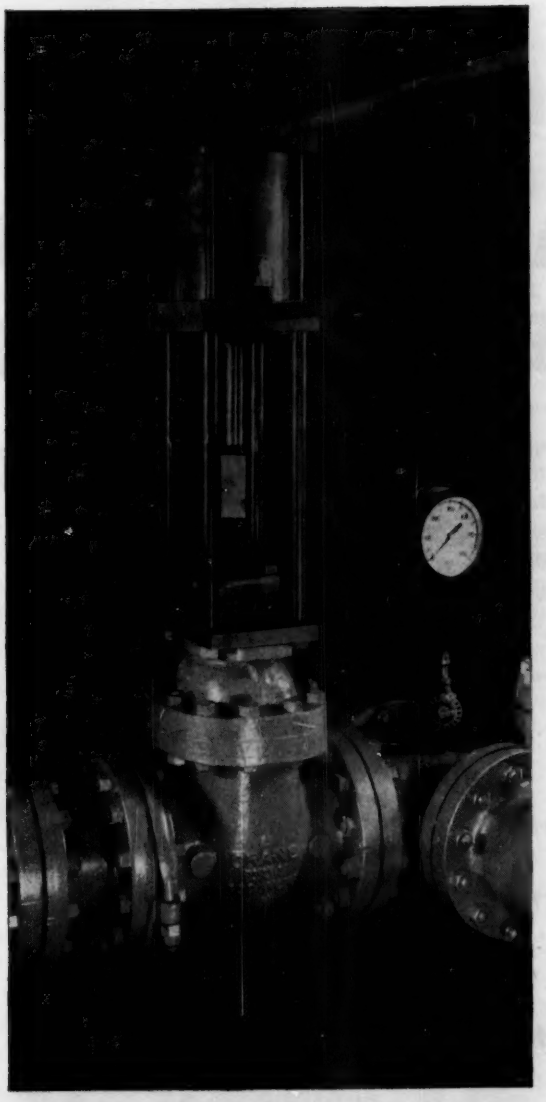
Balanced operation at all flows is based on the baffle. At higher flow rates, gas strikes it at greater velocity. A baffled impulse is transmitted to the lower of two dia-

More New Equipment on Page 144

CRANE
DIRECTION '70

...a fast-moving program of planned expansion, product development, and streamlined distribution to help our customers meet the competitive challenges of the Sixties.

NEW CRANE CYLINDER OPERATORS— LOW-COST POWER OPERATION FOR GATE VALVES



Now you can control any flow process easier and faster with cylinder operated Crane valves. Large valves . . . valves in remote or inaccessible locations . . . valves that must be cycled many times a day...all these can now be operated at the touch of a finger, saving time and manpower. These benefits of power operation are available from Crane now—at lower cost and in less time than ever before!

Crane cylinder operators are available for Crane O. S. & Y. iron body wedge and double-disc gate valves, and for pulp stock valves. Control devices for local or remote actuation supplied at extra cost.

And you can get these new operators for modernization of your present Crane gate valves, too. Easy-to-install adapter is shipped with every cylinder. Field installation can be done in 30 minutes or less, without removing the valve from the line.

This new valve operator is another example of how Crane solves your flow problems more economically, more productively. The Crane solution —the right answer to your flow problems—is as close as a phone call to your Crane distributor. Call him today.

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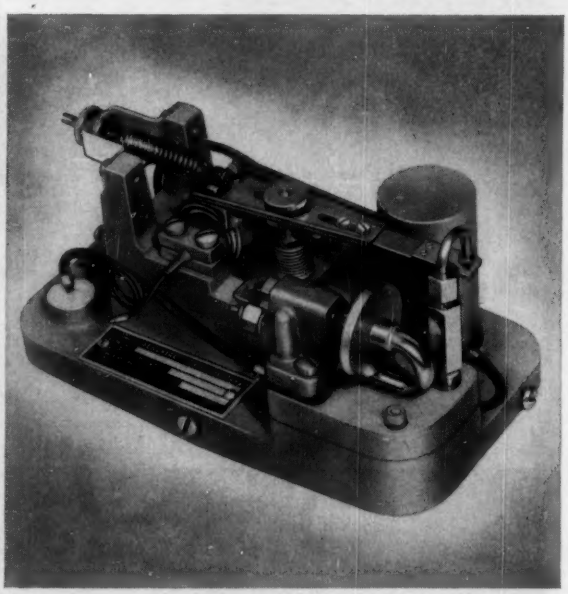
The compact SENSAIRE Transmitter *measures only 7¾" x 4¾" x 4¼". Weighs only 7 lbs. Suitable for many types of application.*

Interchangeable, all-welded thermal system. *Bi-Metal case compensation. Especially desirable on low temperature applications and where mercury is not acceptable.*



New from Taylor... GAS-ACTUATED SENSAIRE* TRANSMITTER

This new version of the time-proven SENSAIRE Transmitter makes low-cost temperature measurement available for those applications where mercury actuation is not acceptable. A force-balance type transmitter, No. 202TG is compact, sturdy and extremely dependable. Adjustments are simplified; repeatability is excellent.

- **Available in 3 range spans.** 100°F., within limits of minus 400°F. to +300°F.; 200° and 400°F, within limits of minus 400°F. to +1000°F.
- **Maximum overrange protection**—100% of range span above operating range.
- **Calibration accuracy** within 1% of range span below 550°F.; 1½% above 550°.
- **Ambient case temperature limits**—minus 30° to +150°F.
- **Air supply**—20 psi recommended; 25 psi maximum.
- **Air consumption**—0.4 scfm.
- **Bulb size**—11/16" x 5⅛". (Optional capillary bulb gives temperature averaging effect. Permits variable immersion with no loss of accuracy.)

Ask your Taylor Field Engineer, or write for **Bulletin 98293.** Taylor Instrument Companies, Rochester 1, New York, and Toronto, Canada.

Easy to install. *Mounts in any position. Universal bracket provides for direct mounting on pipe, wall or wrench head of well or separable bushing.*

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Taylor Instruments **MEAN ACCURACY FIRST**

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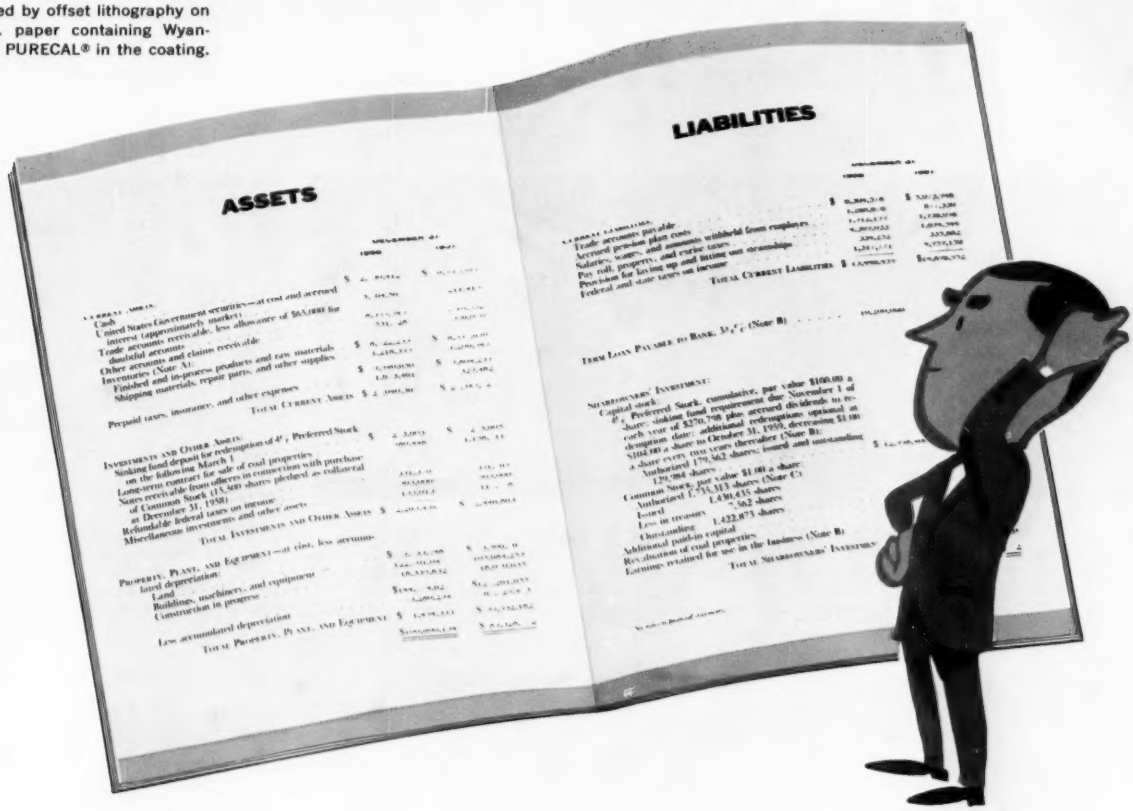


Which side of the balance sheet would you put technical service on?

Actually, and possibly properly so, Wyandotte technical service is not listed as such on either side of our balance sheet, or yours.

At Wyandotte, technical service is a philosophy of doing business. It is a desire, and an effort to be helpful . . . in any way possible. It is an attitude of constructive discontent . . . "There's always a better way. Let's find it!"

Overly optimistic? Perhaps . . . but productive of results!

When you put Wyandotte technical service to work it will—or should—show up on your balance sheet in the form of extra sales and extra profits.

For example: Will a different form of one of our products effect economies in your operation? Are your specifications taking advantage of all of our technical knowledge and product development—to improve your products or to meet competition? Wyandotte technical service is designed to explore questions like these, and others, and make specific recommendations.

Are your facilities for unloading, storing, and handling bulk chemicals as safe and efficient as possible? If not, we'll be happy to help analyze your problems, and suggest improvements.

These are but a few of the functions of our technical service. You can't always classify them . . . but they do have the common purpose of helping you profit fully from the use of our products.

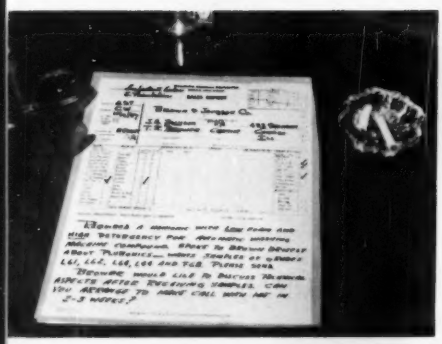
For a pictorial presentation of technical service at work, please turn the page.

WYANDOTTE CHEMICALS

SODA ASH • CAUSTIC SODA • BICARBONATE OF SODA • CALCIUM CARBONATE • CALCIUM CHLORIDE • CHLORINE • MURIATIC ACID • HYDROGEN • DRY ICE
GLYCOLS • SYNTHETIC DETERGENTS • SODIUM CMC • ETHYLENE OXIDE • ETHYLENE DICHLORIDE • POLYETHYLENE GLYCOLS • PROPYLENE OXIDE
PROPYLENE DICHLORIDE • POLYPROPYLENE GLYCOLS • DICHLORODIMETHYLHYDANTOIN • CHLORINATED SOLVENTS • OTHER ORGANIC AND INORGANIC CHEMICALS

Sales follow-up and follow-through

. . . an example of Wyandotte technical service at work



1 A Wyandotte salesman's report indicates that a household-detergent maker is going all out to develop a formulation with low-foaming and maximum detergent properties. Technical service goes into action.

2 Samples of eight grades of Wyandotte Pluronics® block-polymers, data sheets and technical literature are mailed to the research director of the firm. These grades are known to produce the required properties.

3 The literature mailed included Wyandotte's Pluronic Grid*—a graphic description of the properties of all the Pluronics. The technical service man follows up, goes over the Grid with the research director.

4 The eight Pluronics samples are then put through their paces in the company's laboratory, with the Wyandotte technical service man on hand during the final stages. A combination of two Wyandotte Pluronics is soon found to have the best balance of desired properties.

5 Shortly afterward, the first mixed truckload of the two Pluronics is shipped. Schedules are carefully checked. Customer is notified of shipment and its time of arrival.

6 At lunch several weeks later, the technical service man and the research director discuss minor problems encountered in full-scale production of the new household detergent.

FOLLOWING UP the sale is just *one* of the many functions of Wyandotte technical service. Packaging, shipping, safety, handling, storage, new products, new applications, product improvement, better procedures—and more—all fall within the realm of technical service. All come under the heading of giving each Wyandotte customer or prospective customer the service and technical assistance he needs to best use the Wyandotte products he buys.

If you have a problem that falls within our technological or manufacturing background, check with us . . . our approach is designed to provide answers. *Wyandotte Chemicals Corporation, Michigan Alkali Division, Wyandotte, Michigan. Offices in principal cities.*

**If you would like a copy of the Wyandotte Pluronic Grid, just send a note to the address above.*

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CHEMICALS

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SYMBOL OF NEWNESS / 93% of Goulds Pumps shipped to you in the past year were post-1950 design

Over-all view of new distillate hydrotreater shows stripper-fractionator in center, reactor and furnace at right.

Trickle Process Cleans Up Distillates

Shell Oil unit hydrodesulfurizes furnace, diesel oils in liquid phase, boasts savings over vapor-treatment routes.

When operators turned the valves at Shell Oil Co.'s Houston refinery this summer to start up the plant's new distillate hydrotreater, the unit became the sixth one in North America to use Shell's "trickle" hydrodesulfurization process. Incorporating some cost-cutting design improvements, the new hydrotreater has shaved treating costs appreciably, making the unit an attractive proposition for refiners seeking to upgrade petroleum distillates.

Shell's new Houston unit is rated at 30,000 bbl./day, cost about $2 million to erect. It operates as a finishing unit, removing about 90% of the sulfur and about 60% of the nitrogen from furnace and diesel oils on a blocked-out schedule. Oil treated in this fashion is more stable in storage, doesn't form gums or other deposits to clog combustion equipment.

The name, trickle process, refers to the fact that the oil being treated trickles down through the desulfurizing catalyst as a liquid, in contrast to other desulfurizing routes built around vapor-phase catalytic contacting. Advantages that Shell cites for this liquid-phase version are: more intimate catalyst contact, longer residence time and less catalyst coking, all of which bring about significant savings in both capital and operating costs compared with other desulfurizing methods.

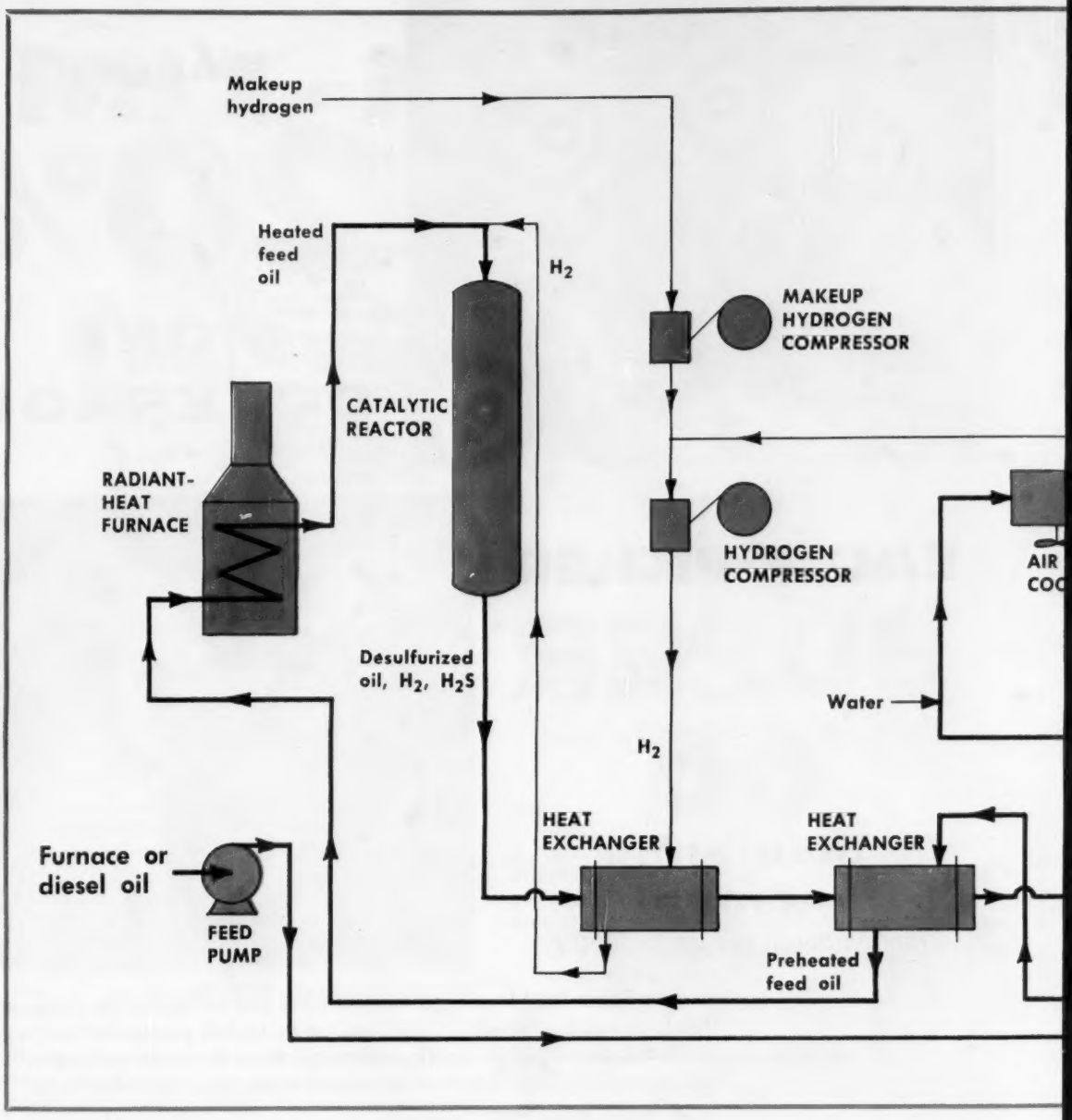
Process employs ordinary desulfurizing catalyst, such as combinations of nickel, cobalt, molybdenum or tungsten supported on a carrier.

▶**How Shell Cuts Costs**—Main money-saving secret in Shell's trickle process is reduction in the amount of hydrogen recycled to the desulfurizing reactor. This reduction not only saves on power costs for compression but also makes possible smaller equipment sizes.

Too, several heat-exchange tricks worked out by Shell designers help save on utility bills. Special, undisclosed catalyst-treatment techniques enable units to operate continuously for one year, and the catalyst can then be reactivated by controlled steam-air burning. After further special treatment, catalyst is good for another year—some units have operated for over three years with the same catalyst.

The new facility is also the first Shell-designed refinery unit that makes extensive use of air cooling—there are three air coolers in the plant. Shell finds that capital cost for such equipment is slightly higher than that of conventional water-

Unfold Flowsheet

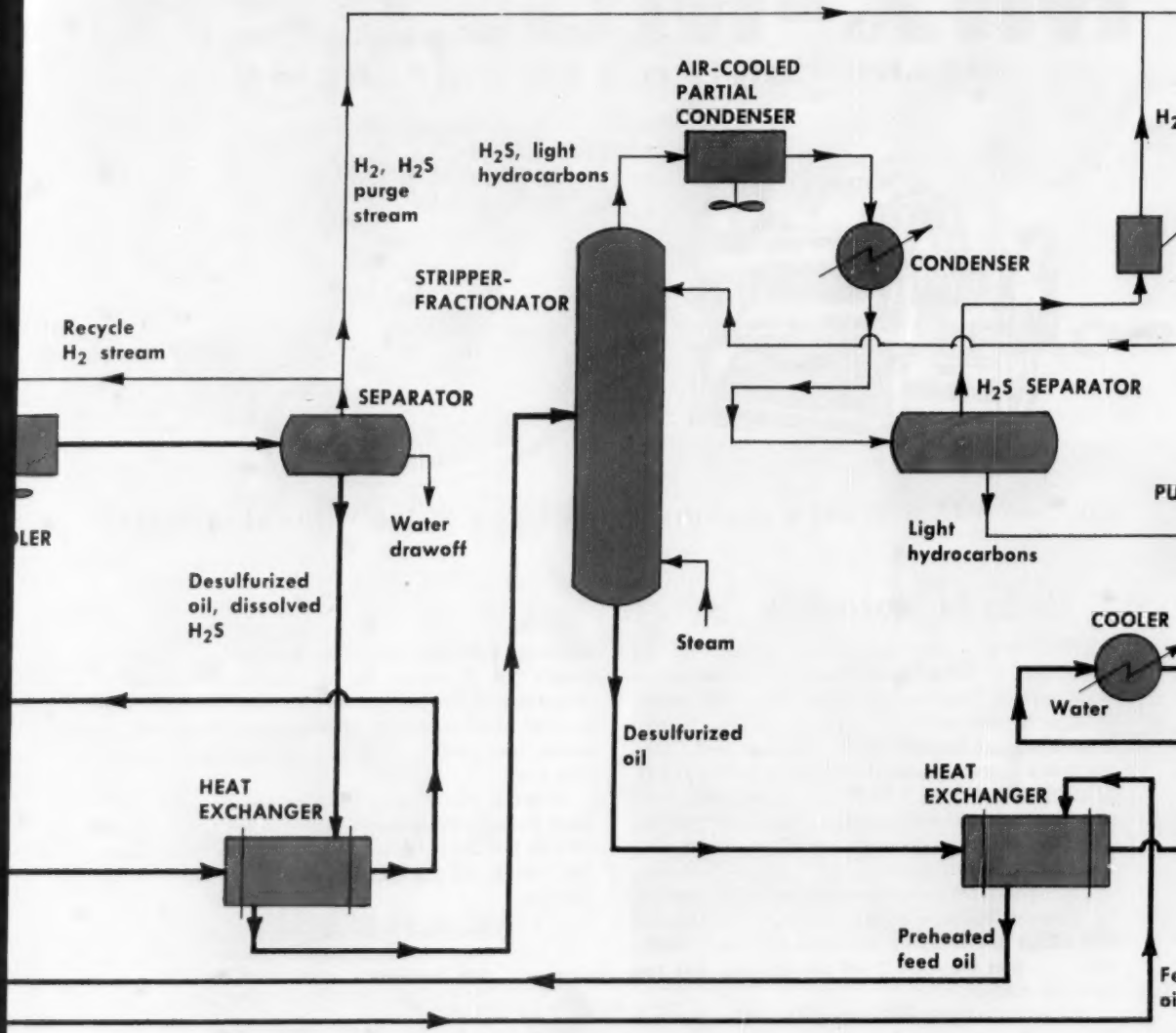


cooled units but that the air coolers soon make up for this in utility, maintenance savings.

► **Blend Before Treating**—Diesel oil treated in the new Houston unit consists of three distillate components; the furnace oil consists of four. Depending on which product is being run, the appropriate components are pumped from Shell's tank farm and blended in the desulfurizer feed line. This blending procedure simplifies problems of storage and production scheduling.

The blended feed is preheated in exchangers and a vertical radiant furnace to about 700 F. Heated stream then contacts hydrogen in a mixing tee just above the desulfurizing reactor. Some of the oil vaporizes because of change in vapor equilibrium but most remains in the liquid phase.

► **In the Reactor**—Oil-hydrogen mixture enters the reactor, is distributed over the top of the catalyst bed by complex distributing devices. As the stream flows down through the bed, sulfur in the oil is reduced to H_2S, many nitrogen compounds are converted to NH_3, olefins are saturated and some



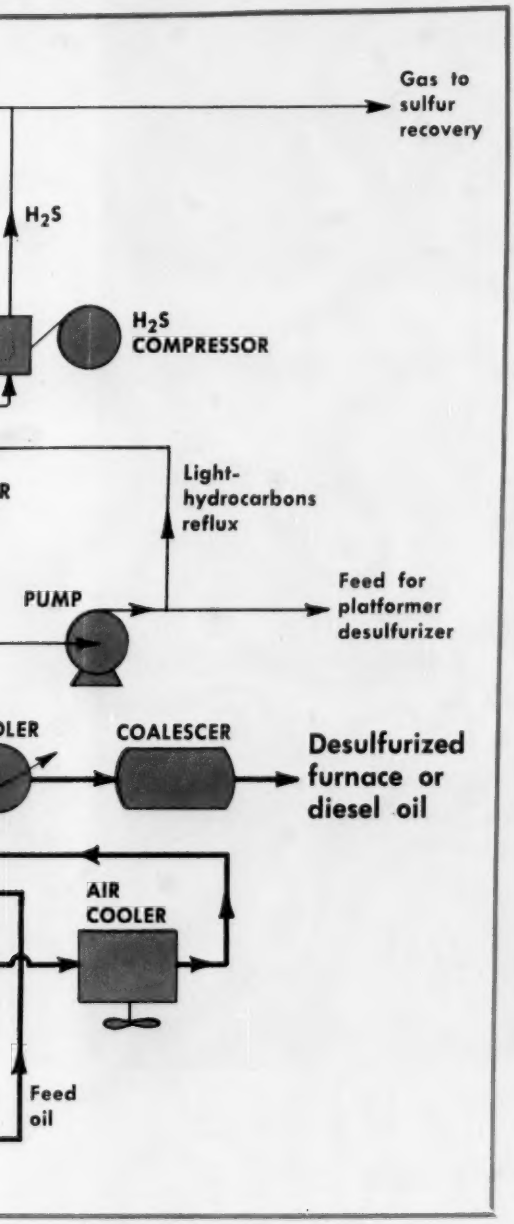
multi-ring compounds are converted to monocyclics. Process is exothermic and the stream undergoes a temperature rise of about 30 F. in the reactor.

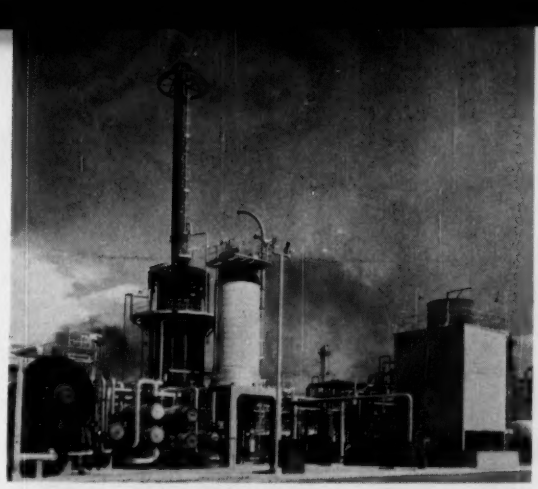
Reactor vessel is designed for adiabatic operation and an exit temperature of 730 F. It is made of carbon-molybdenum steel, lined with stainless steel.

► **Cool and Strip**—Most of the H_2S produced in the reactor dissolves in the oil phase, the rest mixing with the hydrogen. Subsequent steps in the process are designed to reduce H_2S content of the oil to essentially zero.

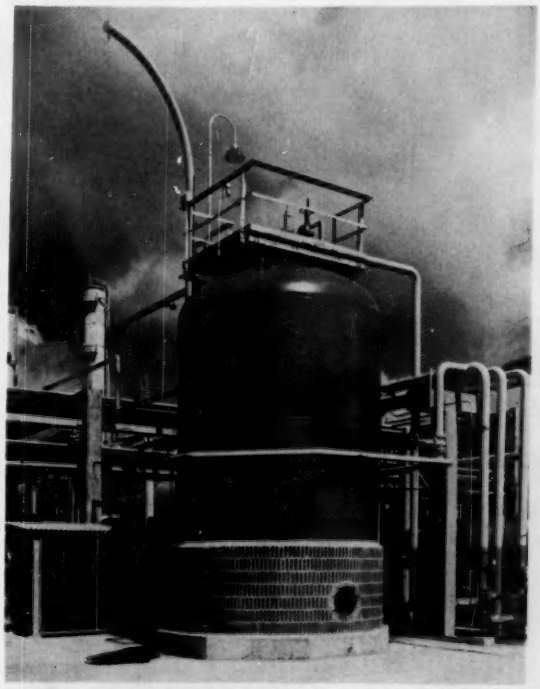
Reactor effluent is cooled in exchangers, then injected with wash water. It next flows to a flash separation system where unreacted hydrogen and some of the H_2S are separated as overhead gas.

Part of the overhead gas stream leaves the desulfurizing unit and goes to sulfur recovery; the rest is combined with makeup hydrogen, then compressed and recycled to the reactor. Makeup hydrogen is about 90% pure, is supplied at a rate





Heart of unit is desulfurizing reactor, center, where hydrogen-oil mixture trickles through catalyst bed.



Last step in process consists of passing product oil through coalescer, above, before storage and sales.

of about 14 million cu. ft./day from two nearby reformers.

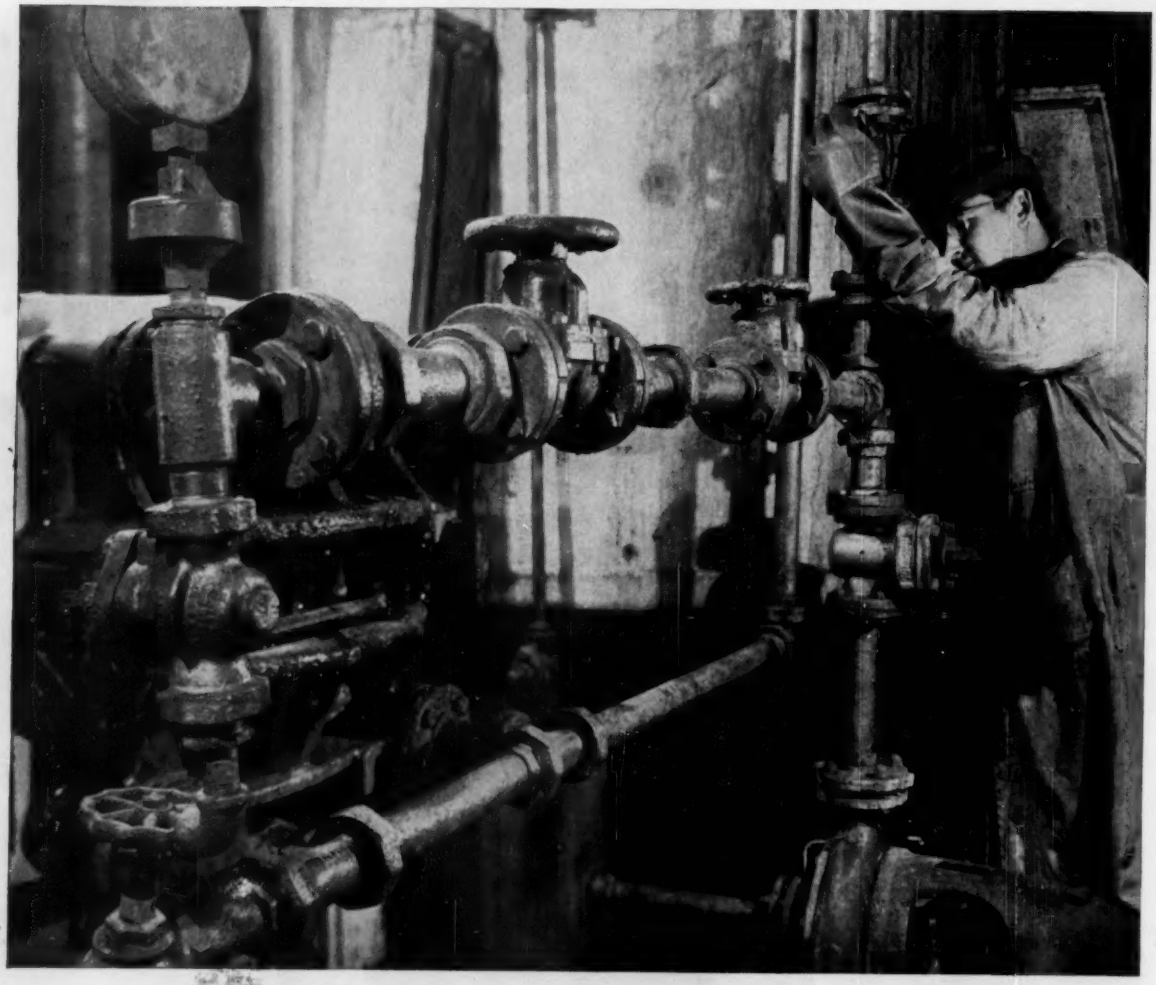
Oil leaving the bottom of the separator is pumped to a steam stripper for removal of the dissolved H_2S. Shell uses reflux on the stripping unit to minimize the amount of oil taken overhead, in order to meet flash point specifications. In this way, the unit combines the advantages of both a stripper and a reboiler-fractionator.

►**Stripper Products**—Product desulfurized oil leaves the bottom of the stripper, is cooled and passed through a coalescer. This bottoms stream is continuously sampled to monitor sulfur-removal performance of the unit.

Overhead from the stripper is cooled, then fed to a separator. Noncondensed gas stream leaves the separator, is compressed and sent to sulfur recovery.

The liquid phase that settles out in the separator contains light hydrocarbons. Part is recycled to the stripper for reflux; rest goes to the desulfurizer of a nearby platforming unit.

DOW | **SARAN LINED PIPE**



After eight years carrying lithium chloride brine . . . No Corrosion in Saran Lined Pipe

When pipe must carry extremely corrosive lithium chloride brine . . . when floor-level installation freely exposes it to danger of accidental damage from trucks and tools . . . doubly protective Saran Lined Pipe can mean dependable, low-maintenance operation for many years.

Lithium Corporation of America's Minneapolis, Minnesota, plant produces pure lithium metal as well as various lithium salts. In the production of lithium chloride, Saran Lined Pipe is used to carry LiCl brine to drying equipment for the removal of water. This brine is extremely corrosive and will quickly eat through steel pipe should a crack develop in the lining. Other Saran Lined Pipe carries suspensions of lithium fluoride and hydrofluoric acid, a combination which will attack and destroy even glass. Because of its strength and extreme corrosion resistance, there's never been a failure in the Saran Lined Pipe.

Saran Lined Pipe at this plant is installed close to floor level in some working areas, constantly exposed to the danger of accidental damage from trucks and tools. Lithium's engineers stated, "Saran Lined Pipe provides protection from outside damage and from corrosion by the solutions carried. In eight years of pumping LiCl brine through Saran Lined Pipe at 30 to 50 psi, there's never been a breakdown, and very little maintenance was required."

Saran Lined Pipe, fittings, valves and pumps are available for systems operating from vacuum to 300 psi, from below zero to 200° F. They can be cut, fitted and modified easily in the field, without special equipment. For more information, write Saran Lined Pipe Company, 2415 Burdette Avenue, Ferndale, Michigan, Dept. 1780 AK10-3.

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Eagle-Picher Super "66" Insulating Cement *sticks to hot or cold surfaces.* It contains a special rust inhibitor that actually *prevents corrosion.* In addition Super "66" is easy to apply . . . reclaimable when used to 1200 F . . . and offers one of the most effective thermal barriers known. Super "66" can be applied on irregular shapes and usually requires no reinforcing on applications up to 1½ inches thick.

Eagle-Picher produces a line of industrial insulations for all temperatures from below zero to over 2000 F. See our complete catalog in Sweet's Plant Engineering File or write for descriptive material.

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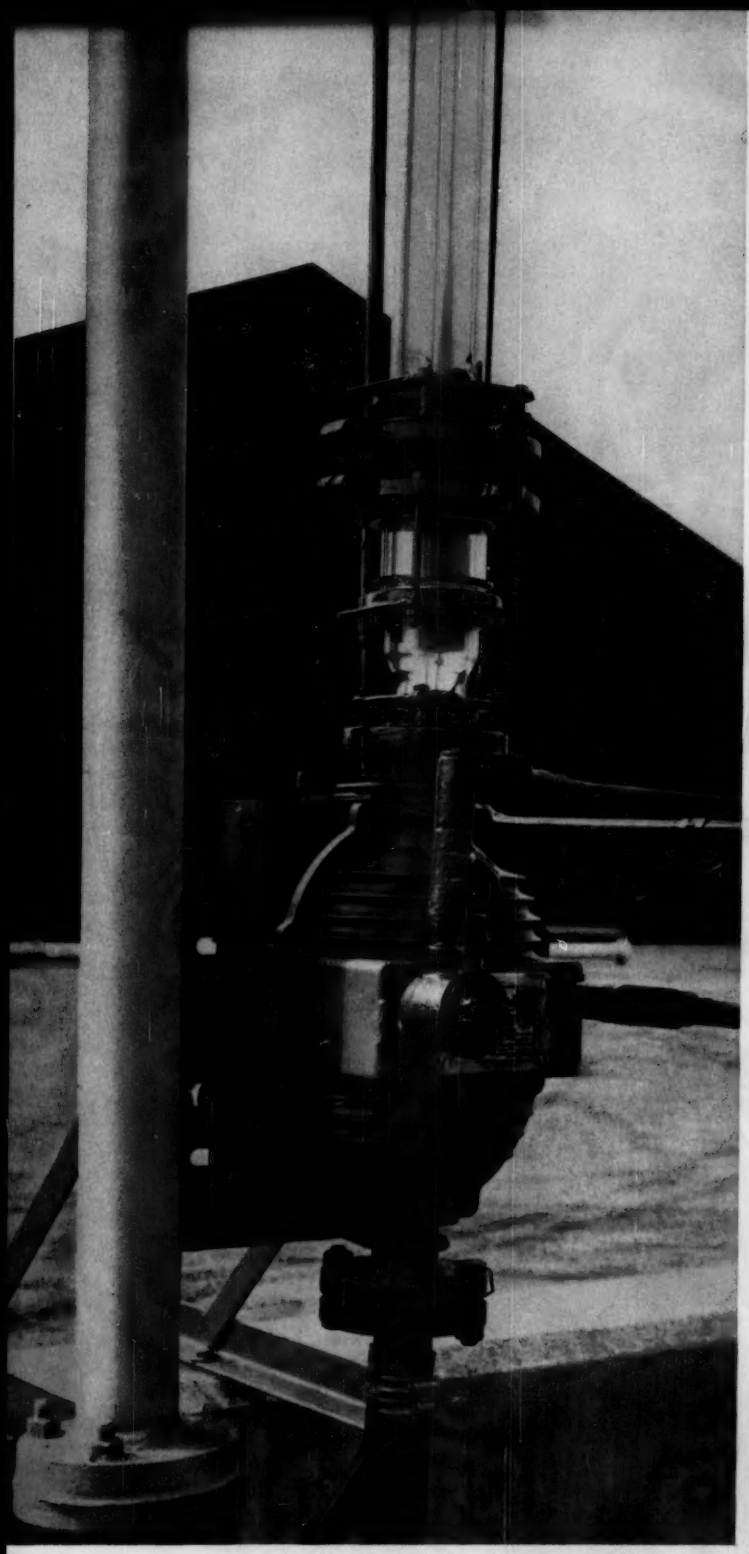

2" Foxboro Magnetic Meter measures 33% hydrochloric acid leaving the Cabot Carbon plant at Tuscola, Illinois. Meter has a Teflon lining, platinum electrodes — completely resists corrosion.

Foxboro Dynalog* electronic recorder logs acid flow. Chart records are attached to customer's monthly invoice as proof of delivery.

*Reg. U.S. Pat. Off.

Corrosive HCL... metered simply, accurately with the Foxboro Magnetic Meter

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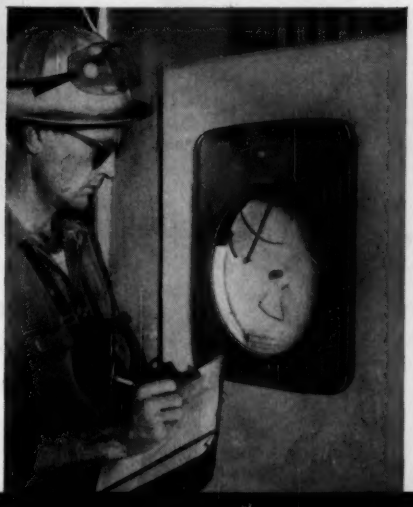

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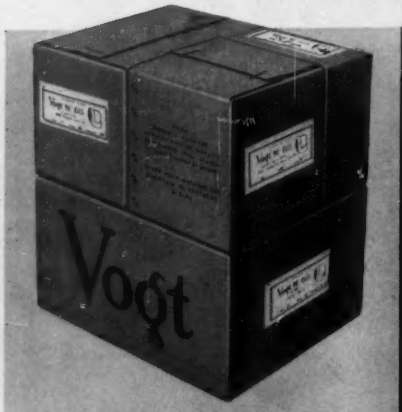

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Selection of containers to package your chemical product shouldn't be made at the last minute. In this special report on packaging, the author describes advantages, disadvantages and costs of various unit containers for solids and liquids.

Containers for Chemicals

THOMAS E. DOWLING
American Cyanamid Co.

In companies where no individual or group is charged with the packaging function, often the last item considered in a product distribution program is selection of a suitable container. Many otherwise successful programs have been marred by insufficient packaging preparation and unsatisfactory container selection.

Perhaps the real reason for avoiding packaging requirements is that many people are not fully aware of available unit containers. Nor are they familiar with container capabilities.

We will discuss here, briefly, the more common unit containers and indicate advantages, disadvantages and typical costs. We will not discuss those packages that are generally called "bulk" containers or those requiring special handling equipment.

Containers considered are those used for packaging liquids or solids. Cylinders and other specially constructed containers for gases are omitted.

Steel drums for liquids

Tight-head and open-head steel drums are, of course, the most popular unit containers for liquid materials in both domestic and export markets.

Drums are made of sheet steel rolled into a cylinder with the side seam joined by welding. Material of construction is preferably cold-rolled steel because it is cleaner and is easier to coat with resin than hot-rolled steel. Acid pickling, detergent scrubbing, shot blasting and other methods of cleaning are also used by drum manufacturers. These assure a better surface to which resin linings and exterior decorative finishes can adhere.

Each end of the cylindrical drum body is flanged slightly to accept top and bottom heads. Heads are stamped, usually from the same weight sheet as the body, and are double-seamed to the body.

Before double-seaming, however, rolling hoops can be swedged or expanded into the body of the drum. If needed, corrugations are expanded into the drum, too. Though at one time rolling hoops were really used as such, they (and corrugations) now primarily stiffen and strengthen the body.

Another fabrication operation before head seaming is stamping out body and end openings and pressing threaded fittings in place. Drums commonly are equipped with a 2-in. opening for filling and emptying and a ¾-in. opening for venting.

A viscous seaming compound is incorporated in the double seam to provide a tight seal. Standard seaming compound used by drum manufacturers has a wide range of chemical resistance,. Where specific resistance is required to prevent leakage, other chemical compositions can be obtained.

Fully removable head drums have only the bottom head double-seamed. Top end of the body is

curled over, and the cover is curled to fit. Ring gaskets for the cover are made of cotton cellulose (plain or polyethylene-covered), square or round sponge-rubber, rubber tubing or rubber compound that is flowed into the curl formed on the cover.

This last type of gasket, if tests show it to be resistant to the product, is certainly the most convenient and reliable to use. Any of the others may be satisfactory, however, but it's recommended that they be cemented in position on the cover to facilitate handling.

Cover is secured to body by a steel closing ring. For an 18-gauge-steel drum, 16-gauge steel provides adequate rings. Two closures are available: a simple ring and bolt and a lever-type device. If ring and bolt are used, a locknut helps maintain tight seal. The more expensive lever device, which may be opened and closed conveniently, is particularly well suited wherever total drum contents are not used at one time.

Providing a drum lining

Resin linings can be applied by hand or mechanical spraying before all parts of the drum are assembled. Steel can be pretreated by sharp-grit blasting, round-shot blasting, phosphate-compound treating ("phosphetizing") or other methods designed to improve adhesion and increase resistance to shock or reverse impact.

Linings, applied to covers and fittings as well as the interior of body shells, are generally baked on in ovens. Pigmented or clear, they generally have a distinctive color that helps in judging correctness of the baking cycle.

Most common linings are made of phenolic resin, epoxy resin or a combination of both. Phenolics usually have greater resistance to liquids of low pH, and epoxies are more resistant to alkaline (high pH) products. Exceptions exist, however, and resin should be checked for resistance to specific products.

Generally, epoxy resins are more flexible and can, with no effect, take greater reverse impact than phenolics. If properly applied, however, phenolics will adhere entirely satisfactorily for most uses.

Weak spots in resin linings are usually at points of irregularity such as at rolling hoops, corrugations, embossing of numerals or other marks, the side-seam weld line, junctures of body and heads (the chime angles) or wherever flanges for openings have been pressed into position. In container test programs, these areas should be inspected carefully for signs of deterioration.

Pigmentation tends to make a coating more impervious to mechanical penetrations of liquids and provides a more continuous film. A pigmented coating costs more than an unpigmented or clear coat, as can be seen from the cost figures in Table II. Specialty linings include vinyl resin, rubber and polyethylene.

Some other considerations for drums

Thought should be given placement of drum openings, with physical setup of filling equipment, customer's discharge requirements and venting procedures the determining factors.

A variety of bung plugs is available, including resin-coated, galvanized, polyethylene and venting types. Closures can be sealed and made tamperproof by cap seals and other such devices. Bung plug gaskets may be made of rubber, asbestos, polyethylene, latex-asbestos, metal-clad asbestos and other materials. On smaller drums, plastic and metal fittings that convert to pouring spouts can be installed.

Available in a wide range of capacities, steel drums commonly can contain 55 or 30 gallons. The 55-gal. units are usually constructed of 18-gauge sheet, but they are obtainable in other thicknesses, from 12- to 20-gauge, with the smaller sizes generally made in lighter gauge sheet. Table I shows actual thickness of the most commonly used gauges.

Most 55-gal. drums are constructed of 18-gauge steel throughout, but because of rising costs and increased competition from other, less expensive containers, greater use is being made of drums constructed of 20-gauge bodies and 18-gauge heads. Saving amounts to about 50¢/unit less than the all-18-gauge unit, and in many cases the "20/18"-gauge drum can be substituted readily. Most 20/18 drums now in use are unlined because of the greater tendency of lighter gauge sheet to dent.

Drums are available also in stainless steel or galvanized sheet as required for specific product protection.

Note, from the cost figures in Table II, that stainless steel, galvanized and all heavy-gauge drums are relatively expensive; generally, they're used as "deposit" or returnable containers.

During recent years, however, the trend throughout industry has been away from returnable containers. Not only is deposit required from the customer—a sales deterrent in many instances—but additional

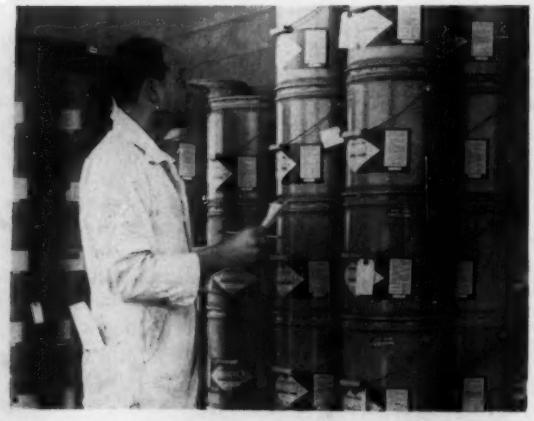
Steel sheet thickness—Table I

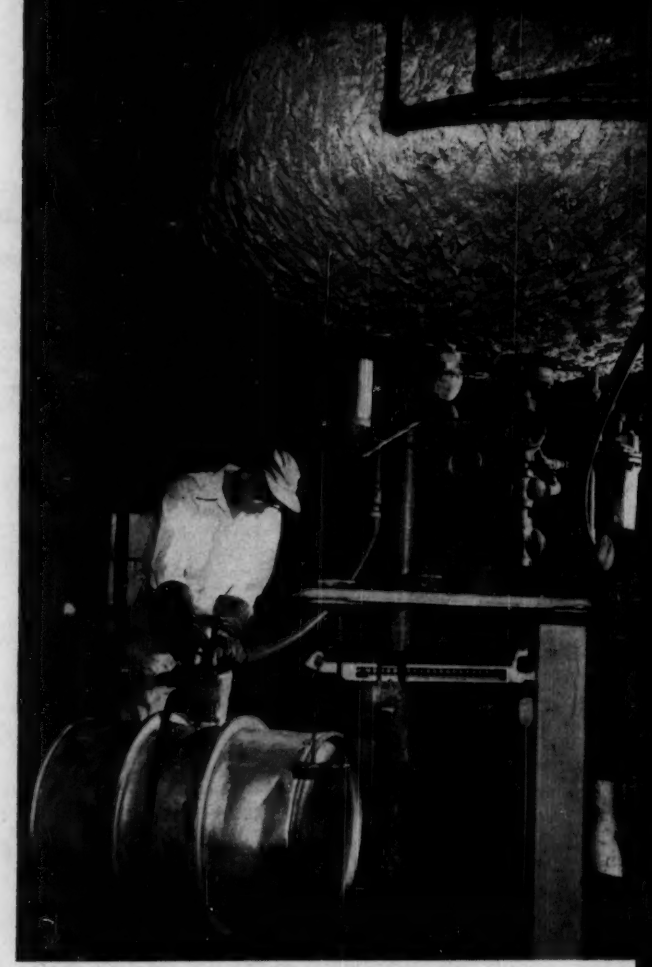
Gauge No.	Nominal Thickness, In.	Minimum Thickness, In.
12	0.1046	0.0946
14	0.0747	0.0677
16	0.0598	0.0533
18	0.0478	0.0428
19	0.0418	0.0378
20	0.0359	0.0324
22	0.0299	0.0269
24	0.0239	0.0209
26	0.0179	0.0159
28	0.0149	0.0129

Approximate 1960 costs of liquid and solid unit containers—Table II

Container Description	Unit Cost[2]
Steel drums[1]	
55-gal., tight-head, 18-gauge, 2-in. and ¾-in. openings, unlined[3]	$6.00
55-gal., removable-head, 18-gauge, unlined[3]	6.40
30-gal., tight-head, 20-gauge, 2-in. and ¾-in. openings, unlined[3]	4.80
30-gal., removable-head, 19-gauge, unlined[3]	5.60
55-gal., tight-head, 16-gauge, 304 stainless steel, 2-in. and ¾-in. openings	90.00
55-gal., tight-head, 12-gauge, acid-type fittings, carbon steel, ICC 5A	27.00
55-gal., tight-head, 12-gauge, aluminum, 2-in. and ¾-in. openings	40.00
55-gal., tight-head, 16-gauge, galvanized, 2-in. and ¾-in. fittings	12.00
45-gal., tight-head, 22-gauge, 9-in. friction lid, unlined[3]	4.00
30-gal., tight-head, 24-gauge, 9-in. friction lid, unlined[3]	3.10
16-gal., removable-lug cover, 22-gauge, unlined[3]	2.50
55-gal., used, tight-head, 18-gauge, unlined[3]	4.50
55-gal., reconditioned, removable-head, 18-gauge, unlined[3]	4.50
55-gal., rebuilt, tight-head, 18-gauge, unlined[3]	4.75
[1] Unless noted, drums are made of cold-rolled, black steel.	
[2] Cost figures are approximate, intended only to show order-of-magnitude.	
[3] Baked-resin drum linings cost about $0.65 per coat, pigmented ones cost about $0.80 per coat.	
Fiber drums[4]	
50-gal., duplex PE liquid-tight barrier, removable metal cover and closing ring	5.75
55-gal., semirigid liquid-tight PE liner, removable metal cover and closing ring	7.00
15-gal., duplex PE liquid-tight barrier, removable metal cover and closing ring	3.30
55-gal., no moisture barrier, removable metal cover and closing ring	2.50
30-gal., no moisture barrier, removable metal cover and closing ring	1.90
55-gal., aluminum-foil moisture barrier, removable metal cover and closing ring	3.00
30-gal., aluminum-foil moisture barrier, removable metal cover and closing ring	2.20
55-gal., asphalt moisture barrier, removable metal cover and closing ring	2.75
30-gal., asphalt moisture barrier, removable metal cover and closing ring	2.05
15-gal., no moisture barrier, telescoping fiber cover	1.00
15-gal., asphalt moisture barrier, telescoping fiber cover	1.20
5-gal., no moisture barrier, telescoping fiber cover	0.65
5-gal., asphalt moisture barrier, telescoping fiber cover	0.80
1-gal., asphalt moisture barrier, telescoping fiber cover	0.50
[4] Unless otherwise indicated, fiber drums are intended for use with solid products and are not liquid-tight.	
Multiwall paper shipping sacks[5]	
5-ply M/W bag, sewn valve construction, PE moisture barrier, 38-in. long × 19-in. wide × 5-in. thick	0.20
5-ply M/W bag, pasted valve construction, asphalt moisture barrier, 32-in. long × 21-in. wide × 6-in. thick	0.15
3-ply M/W bag, sewn valve construction, all extensible kraft, 31-in. long × 16-in. wide × 5-in. thick	0.10
2-ply M/W bag, pasted open-mouth construction, all extensible kraft, 40-in. long × 20-in. wide × 9-in. thick	0.08
4-ply M/W bag, sewn open-mouth construction, no moisture barrier, 38-in. long × 19-in. wide × 5-in. thick	0.12
6-ply M/W bag, sewn valve construction, PE moisture barrier, wet-strength outer ply, 40-in. long × 19-in. wide × 5-in. thick	0.28
[5] All bags made of natural kraft unless otherwise indicated.	
Burlap bags	
10-oz., open-mouth flat-tube construction, no moisture barrier, sewn seams, 34-in. long × 24-in. wide	0.20
Waterproof paper-lined bag (WPPL), 10-oz. burlap, valve-type flat-tube construction, single ply of creped kraft laminated to burlap with asphalt, cemented seams, 28-in. long × 22-in. wide	0.30
Steel pails	
5-gal., tight-head, 26-gauge, PE pouring spout, unlined[6]	1.10
5-gal., removable-head, 26-gauge, lug cover, bail handle, unlined[6]	0.90
1-gal., tight-head, 26-gauge, PE pouring spout, unlined[6]	0.90
[6] Baked-resin pail linings cost about $0.10 per coat, pigmented ones about $0.14 per coat.	
Miscellaneous	
13-gal. glass carboy, wood box	15.00
15-gal. semirigid PE liner unit with spout, wood-wirebound overpack	3.50
5-gal. semirigid PE liner unit with spout, corrugated fiberboard overpack	0.80
5-gal. semirigid PE liner unit with spout, steel pail overpack	2.00
55-gal. rigid PE drum (0.0625-in. thick) with standard 55-gal. steel drum overpack, standard 2-in. and ¾-in. openings	25.00
13-gal. PE carboy, welded-steel-rod crate overpack	20.00
13-gal. PE carboy, cylindrical plywood overpack	20.00
Polyethylene flat-tube bag, open-mouth construction, 7-mil high-density PE, 38-in. long × 19-in. wide	0.20
Polyethylene flat-tube bag, open-mouth construction, 2-mil high-density PE, 38-in. long × 19-in. wide	0.09
32-fluid-oz. (1 qt.) flint glass jug, finger handle, cap with PE liner	0.20
1-qt. round friction-lid tin can, "paint" type	0.15
1-qt. oblong tin can with screw cap and handle on top	0.20
Corrugated fiberboard regular slotted container (RSC), 200-lb.-test board, 20-in. long × 15-in. wide × 10-in. deep	0.20

Carboys—glass or polyethylene bottles enclosed in shipper of wood—are used for HCl, elsewhere for other corrosives.





Steel drums can contain either liquid or solid. Here being used in liquid service, drum is filled manually by operator. Often, these popular containers are re-used, reconditioned.

Steel pails are nearly as versatile as steel drums, but they come in smaller (1-10-gal.) size. Shown (left) with wire bail handles and wood grips, containers are easily stored.

paper work is required of the supplier and the customer. Containers are still used on "turnaround" basis, but this is the exception. Such instances generally involve shipments between adjacent plants or where the procedure can otherwise be rigidly controlled.

Though returning containers has declined, in captive service many drums are re-used with minimum treatment such as rinsing. But they can also be reconditioned: burned out, sand-blasted, "chained" clean, de-dented, relined, repainted and otherwise treated for further use in certain domestic and export services, if no regulatory agency specifically excludes their re-use.

Always keep in mind, however, that once-used or reconditioned drums are not new drums; they should not be expected to meet new-drum performance. The sheet metal they're made of is subject to metal fatigue through transportation vibration and handling.

There is naturally a greater possibility of leakage and contamination with a used or reconditioned drum than with a new one. With certain products and in special situations, however, these units have proved highly satisfactory, and, as can be seen in Table II, significant savings are possible.

Rebuilt steel drums are available from some suppliers, too. These used units have had one head removed, the interior cleaned and relined, if necessary, and a new head seamed on. Costing less than new drums, the rebuilt units should not be expected to match new-drum service.

Within the past several years, a set of standard dimensions has been adopted by the steel-drum manufacturers for the most popular size drums. This assures that drums of same capacity obtained from different sources will have identical heights—a feature of paramount importance when shipping palletized, stacked units.

Standardizing container sizes is a matter that should be considered seriously by manufacturers of all types of containers. Cost advantages, both to manufacturers and users, are obvious. For example,

the most advantageous dimensions for export cubage have been selected for steel drums, thus cutting export shipping charges.

Customer requirements for drums in liquid service may often call for a steel drum with a fully removable head. Liquids covering a wide range of viscosity have been packaged successfully this way. However, as mentioned before, it's important to install the cover and to effect a closure that is tight when the drum is filled and that will remain tight during shipment.

Using Fiber Drums For Liquids

Using wood pulp as raw material of construction, fiber drums have been developed that are capable of containing not only paste-like materials but thin, mobile liquids as well. Bodies are convolutely wound of many kraft-paper plies bonded together with suitable adhesives. The fiber bodies (and bottoms) have steel-reinforced end chimes and steel removable covers with closing rings of the convenient lever-action type.

One type of construction features a duplex barrier film of a polyethylene-based resin that is wound in with kraft plies when the drum is made. In the finished container, the inside ply is 4–5-mil thickness of film and the third ply from inside is 1–1¼-mil film. Bottom head has the same construction and is also waxed outside to retard water absorption from damp surfaces.

Body and bottom head are seamed together and reinforced with a steel chime ring. Seaming compound effects a good seal to prevent leakage, but, as with steel drums, special seaming or caulking compound may be required for chemical resistance to specific products.

The removable metal cover has a chemical-resistant resin coating, and a flowed-in annular rubber gasket provides a tight seal between cover and drum.

Although fiber drum containers haven't been approved by Interstate Commerce Commission for use with "flammable," "poisonous," or other hazardous materials, they have been accepted by Uniform Freight Classification (UFC) and National Motor Freight Classification (NMFC) for ladings of nonhazardous materials up to 700-lb. net.

The containers have found increased favor recently in domestic shipments of paper chemicals, wetting agents, some intermediate chemicals, etc. Only a few are used in export service, and these are generally the smaller sizes, but perhaps improved handling methods will increase this service.

As might be expected, fiber drums are unable to withstand outside storage as well as steel drums. Too, their stacking strength is lessened under conditions of continuous high humidity.

If protected by special exterior surface treatments, however, or if they are properly stored under cover, fiber drums can be safely stacked several tiers high. If outside storage is anticipated, extra cost of features that make fiber drums exposureproof should be considered carefully. And even though fiber drums may not be exposed to weather, conditions at point of use might require special protective features; again, examine costs closely.

Because they minimize possibility of iron and other contaminants entering, fiber drums are used primarily as substitutes for more-expensive, lined steel containers or for returnable stainless steel or galvanized drums. The relative light weight of the fiber containers offers shipping charge savings over a steel drum of equivalent capacity.

Still, a customer may only reluctantly accept fiber drums. They may not be suitable for re-use by him, and the used-fiber-drum market is not as strong as its steel-drum counterpart. Despite these disadvantages, lower cost and weight have made fiber drums increasingly popular.

Steel Pails For Smaller Amounts

Tight-head steel pails, unlined or lined with the same linings available in steel drums, are made in 1–10 gal. sizes. With heads double-seamed (like drums), pails come equipped with metal handles centered on the top, or with wire-bail handles and wood or plastic grips.

Regular bung plugs, polyethylene pouring spouts and metal pouring spouts can be installed. Such fittings must be crimped on with a special tool after pails are filled. Fittings serve as tamperproof seals until pail is opened by user.

Pails with fully removable heads, lug-type covers and flowed-in rubber gaskets are also used extensively for liquids shipment, particularly for high-viscosity liquids.

Because tops or bottoms of the pails can be necked in to permit interlocking for stacking, pails lend themselves to unitizing. Filled pails can be stacked easily on wooden pallets to a total gross weight of 2,000 lb. Complete unit, with pails held together by wooden slat stringers or corrugated fiberboard trays, is usually wire-strapped to the pallet.

Like steel drums, pails can be made to comply with ICC and other regulations as required. And they can be decorated readily by silk screen or lithograph.

Plastic-Plus-Overpack Containers

Another group of containers gaining favor in many quarters is that which combines a polyethylene (or other plastic) unit with an overpack—a steel drum or pail, a wood-wirebound box, a corrugated fiber box, a fiber drum, or some other container. PE unit may be 20 mils thick and essentially rigid, or it may be relatively thin and semirigid or flexible.

In one unit of this type, a semirigid PE liner, tapering in thickness from 20 mils at the bottom to 11 mils at the top, is fitted into a fiber drum with steel-reinforcing chimes at top and bottom. Top of the polyethylene liner folds over top chime of drum,

and a PE-lined metal cover with appropriate fittings is secured to drum with a metal, lever-action closing ring.

As can be seen in Table II, costs vary greatly, the more expensive units used for returnable service and the less expensive for single-trip service. In some cases, only the inner plastic unit is replaced after a single trip; the overpack serves for several.

Closures are the greatest problem with these containers. In the past year, however, these have been improved to give satisfactory service under rigorous conditions.

A common error in selection of these containers is to assume that polyethylene or PE-type resin barriers are impervious to all chemicals. Actually, they are penetrated readily by many products and must be tested for specific service. Manufacturers of PE and other plastic containers have a wealth of test information as well as complete test facilities for new-product trials.

Perhaps it is here that the greatest packaging strides will be made in the future. Certainly, it's not unreasonable to believe that plastics of superior mechanical, physical and chemical properties will be developed.

Some other special containers

Other liquid containers are less frequently used, but they are highly satisfactory for special purposes. They include:

• Carboys—A 5-15-gal. glass or polyethylene bottle enclosed within an outside shipper of wood, plywood, welded-steel rods or other suitable material and used for acids and other corrosive liquids.

• Aluminum drums—Similar in appearance to steel drums, they are, because of cost, only practical in returnable service. Though lighter and less expensive than the same capacity stainless drum, they tend to dent more readily than steel drums. When compatible with product, and shipping weight makes a difference, aluminum drums are ideal in captive service.

• Tin cans—Used for shipment of one gallon or less, cans are round, with friction lids, or rectangular, with screw-top closures. Available in various tinplate thickness, cans also may have resin linings to extend their usefulness. They're particularly convenient for ICC-regulated commodities in small shipment.

• Bottles and jars—Made of glass or plastic, these small-quantity containers require carefully selected caps and cap liner material. Materials for former include phenolic and styrene resins, for latter: aluminum foil-pulp, vinyl-pulp and polyethylene.

• Other units incude loose plastic-film bags in corrugated boxes; liquid-proof, aluminum-foil-lined kraft bags; etc., but are of limited application.

Multiwall bags for solids

Multiwall paper shipping sacks are used universally for packaging of powdered, granular and lump materials. Unique among containers, they can be exactly tailored to fit size and strength requirments of the product they hold.

Made from continuous rolls of heavy-duty kraft, multiwall bags have 2–6 plies tubed and nested so that each ply carries its share of the load. Minimum standards for kraft are outlined in Federal Specification UU-S-48.

Ply is specified by weight of a ream of 500 sheets of 24 in. × 36 in. of the kraft. For example, bag construction might be 1/50, 1/60, 1/70. This means it's made of three kraft plies—a 50-lb. ply on the inside, a 60-lb. ply in the middle and a 70-lb. ply on the outside. Total basis weight of the bag is 180 lb.

Multiwall bags are made in two basic styles—open-mouth and valve—either of which may be of "sewn" or "pasted" construction. Open-mouth bags are filled through the open top, closed by sewing, typing or gluing. Valve bags are filled through a small valve or opening in one corner of the otherwise closed bag. Closure is by manually folding an external paper sleeve or by check-valve action of an internal paper sleeve.

In a "sewn" bag, end closures are made by sewing, and in a "pasted" bag they are glued. Side seams of both, staggered to distribute strength more evenly, are glued.

In a sewn bag, the most common end closures are made by sewing with cotton or rayon thread through paper tape. This type of closure is the strongest and least expensive, but it does not offer much in the way

of moisture protection or siftproofness. These characteristics can be had by specifying pressure-sensitive tape over sewing, PE-laminated-to-kraft tape heat-sealed over the sewing, or asphalt-laminated-kraft tape applied over the sewing line with latex adhesive.

In a pasted bag, the end closures are available in a number of design variations offering degrees of siftproofness, flexibility and strength. Perhaps the latest in pasted-bag end closure design is the "stepped-end" construction in which ends of each individual ply are glued to themselves, all ends being joined in step fashion.

Stepped-end construction is available only in a limited range of sizes. Because of lengthy machine set-up time required to make the closures, it's generally used in large-volume service, such as for cement.

Pasted construction has become more popular in the past few years for several reasons. It fills out to a squarer unit with straighter sides, forming a more stable palletized load.

The pasted bag fills out more completely in corners and edges of bag; this means less paper per bag and less cost than otherwise equivalent sewn bag. Flat end and edge surfaces are good areas for printing so that more effective decoration and design is possible, particularly on palletized units that expose such edges.

Moisture barriers for multiwalls

Various moisture barrier plies may be added during construction, depending on product protection requirements. One, known as asphalt-laminated sheet (AL), is made by sandwiching asphalt between two plies of kraft. A 90AL ply is made of 1/30 kraft, 1/30AL, 1/30 kraft.

Though not as effective as others, asphalt-laminated barriers are among the least expensive. Where only a little protection is required they are satisfactory. But they are stiff and hard to handle in cold weather, tend to gum up needles on sewing equipment, may bleed through if product is packed hot, and contaminate pulp in a paper beater if that is the method of disposal.

More popular is the moisture barrier made by extruding a thin film of polyethylene to kraft. It can be sewn through easily, remains more flexible than asphalt at low temperatures, is unaffected by products packed as hot as 190 F. Too, bags empty cleanly when these barriers are used as the inside ply.

Although manufacturing methods have improved so that it's possible to use thinner and less-expensive films with equivalent protection, these barriers are still among the most expensive. But a few years ago, a 20-lb. PE film provided only as much protection as a 10-lb. film does today. High-density PE resins are also available, more expensive pound for pound than low-density but less expensive in bag construction because thinner film does the same job.

A glassine sheet can be built into a bag when greaseproofness is required. For both moisture and odor barrier, a wax-impregnated kraft sheet may serve. Aluminum foil is used also as a moisture barrier.

To determine kind of barrier required, sample bags with various moisture barriers should be filled with the product and stored in environment similar to that expected in service. If tests are run with sheets rather than bags, the sheets should be tested "creased" rather than flat. Results will be more truly indicative of regular bag performance. The most common test to evaluate relative effectiveness of moisture barriers is the ASTM Test Method E96-53T.

A recent innovation is the offering by one bag manufacturer of a moisture barrier sold in terms of performance rather than thickness of film, density of resin, etc. It makes sense to buy a desired degree of protection rather than trying to adhere to rigid material specifications. Other factors being acceptable, it doesn't matter how a bag manufacturer provides protection as long as the user gets that which the product needs.

Strength and Bag Construction

Many special features are available to multiwall bag users. They include:

- Wet-strength kraft—a regular kraft to which melamine resin has been added during manufacture —that retains a significantly greater portion of its strength when wet.
- Antiskid treatments that help maintain stability in palletized units. Treatments may consist of colloidal silica sprays, rough-finish kraft, heavy coverage of bag with nonskid types of printing inks, creped kraft paper, etc.
- Fiber-free inside plies, for critically pure products, that may be PE-coated kraft plies, high-finish kraft paper, glassine-type sheets and others.

An important innovation in bag construction was the introduction of extensible kraft paper. This is kraft provided with a built-in stretch or toughness factor. Absorbing more shock and punishment than regular kraft bags before breaking, extensible kraft bags of perhaps 10-15% less total basis weight may

Relative effectiveness of multiwall-bag moisture barriers—Table III

1. Aluminum foil
2. 1/20 high-density PE 50
3. 1/15 high-density PE 50
4. 1/10 high-density PE 50
5. 1/20 regular-density PE 50
6. 1/15 regular-density PE 50
7. 1/8 high-density PE 50
8. 1/10 regular-density PE 50
9. 2/90 AL
10. 30 kraft/20 microcrystalline wax/30 kraft
11. 1/90 AL
12. Wax-impregnated, 50-lb. kraft
13. 50-lb. natural kraft

Note. When it is severely creased, aluminum foil can develop pinholes and lose considerable effectiveness. PE barriers aren't significantly affected by creasing.

give equal or superior performance and save some money, too.

Extensible kraft can be made with all conventional barriers such as PE and asphalt; with rough or smooth finishes; in bleached, semibleached or natural kraft. It takes printing very well.

Multiwall bags should have just enough strength to satisfactorily contain the product and deliver it to the customer safely and in good condition. This keeps cost at an optimal minimum. Keep in mind that a small percentage of breakage (less than ½ of 1%) often occurs unless bags are grossly overconstructed.

Because of this normal breakage, multiwall bags are not usually used for expensive products—those costing upwards of $1/lb. If construction is selected carefully, however, and packing and shipping are well-controlled, even shipments of products as expensive as this can be made.

With any number of excellent packing machines, multiwall bags afford perhaps the fastest and least expensive way of packaging solid materials. Packing speeds of up to twenty 100-lb. bags per minute can be achieved with complete automation and with packing weight accurate to ±4 oz. With a simple hopper, valve and scale, one to two 100-lb. bags can be filled per minute.

Bags can be handled as individual packages or, with common powered equipment, as palletized units of 1,000, 1,500 or 2,000 lb. In the domestic market, the trend has been away from 100-lb. units and toward 75- and 50-lb. units, particularly for products that the consumer handles by individual package. For the export market or unitized shipments, however, 100-lb.-net bags are completely satisfactory.

When bags are shipped in palletized units or in full carload or truckload quantities, it's usually possible to use a somewhat lighter construction than when they are shipped as single units or in less-than-carload or truckload lots.

As a rough guide, domestic bags have from three to five plies and total basis weight of 140-280 lb. Export bags usually have five or six plies with total basis weight of 270-350 lb. And even if product is not hygroscopic, export bags often contain a moisture barrier and/or a wet-strength outer ply to guard against unusual outside exposure.

Use Burlap For Ruggedness

Burlap bags are sometimes used for more rigorous export service and where exceptionally abusive transportation conditions are expected. These bags may be of single-ply burlap slipped over standard multiwall kraft bags with the top sewn closed. Or they may be of burlap laminated to creped kraft paper with asphalt to form a waterproof, paper-lined unit.

Another lamination sometimes used consists of polyethylene film laminated to burlap with special adhesives.

Burlap bags are available in sewn open-mouth or valve types and in various weights of material, such as 7½, 10 or 12 oz. Seams may be sewn, cemented or both. Limited by widths of available burlap sheeting, size selection is less flexible than that of multiwalls.

Burlap is used in another type of bag in which the fabric is sandwiched between two sheets of kraft and laminated to the kraft with asphalt. This is a far cleaner bag than those described above. It minimizes product contamination and provides a superior surface for printing, but retains the toughness of burlap.

Over-all use of burlap has declined considerably in the last 15 years, however. This is primarily because of advances made in other, less-expensive containers, but uncertainties of the burlap (or jute) market also contribute.

Fiber Drums For Solid Materials

Fiber drums enjoy wide popularity and have great advantage in shipment of many solids. They are tough but also lightweight and easy to handle.

Made entirely of fiber, or a combination of fiber and steel and/or wood, the bodies are convolutely wound with about 8-10 plies of kraft banded together over their entire surfaces with suitable adhesive.

Metal-fiber drums have metal end reinforcements, bottom heads double-seamed to the drum bottoms. The cover is made of 24- or 26-gauge-steel sheet that is coated with baked resin, and it carries a flowed-in rubber gasket.

Cover is secured to drum body with a lever-action metal closing ring. At this stage of manufacture, moisture barriers or other special plies are built into the drums. Common moisture barriers for fiber drums are polyethylene, light- and heavy-duty inside plies; aluminum foil buried in the sidewall; asphalt buried in the sidewall; and glassine inside ply (for greaseproofness).

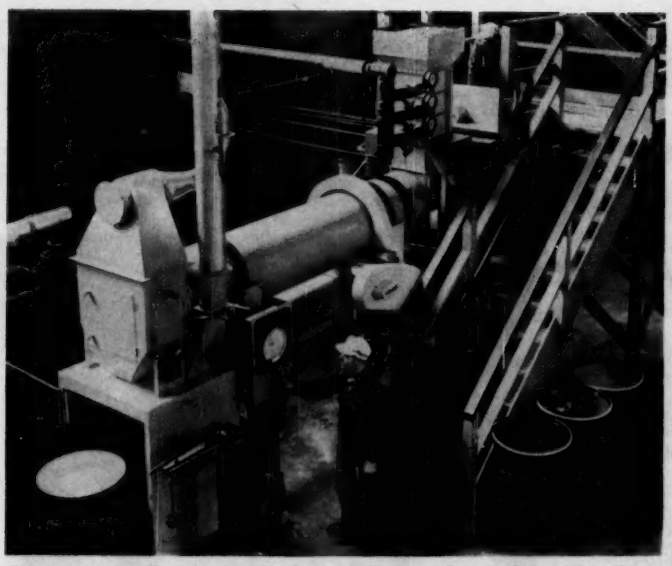
Fiber drum containers for solids range in size from ¾-gal. to 67 gal. The all-fiber-construction drum, with telescoping or friction lid, generally is used in 3-gal. to 15- or 20-gal. size; it is made, however, as large as 67 gallon. In the 20-67-gal. sizes, steel-fiber units usually are preferred.

Depending on net weight of product to be packed, several constructions of drum can be obtained in any given size. As with multiwall bags, only as much strength as is specifically required need be purchased.

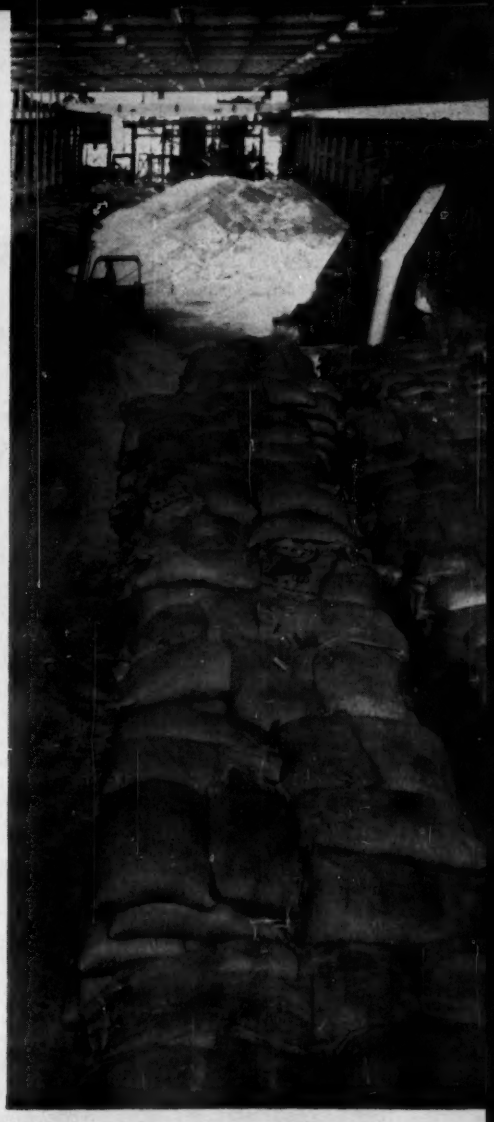
Drums of any given capacity are made in two different diameters and two different heights. This permits shipping "nested" empty containers with resulting savings in freight charges. It presents two problems, however: the need to "un-nest" each drum and the interference of two different heights with pallet storage.

Again, fiber drums are not suited to outside storage unless they are given special exterior treatment. This may be clear varnish, paint, PE ply on outside, and

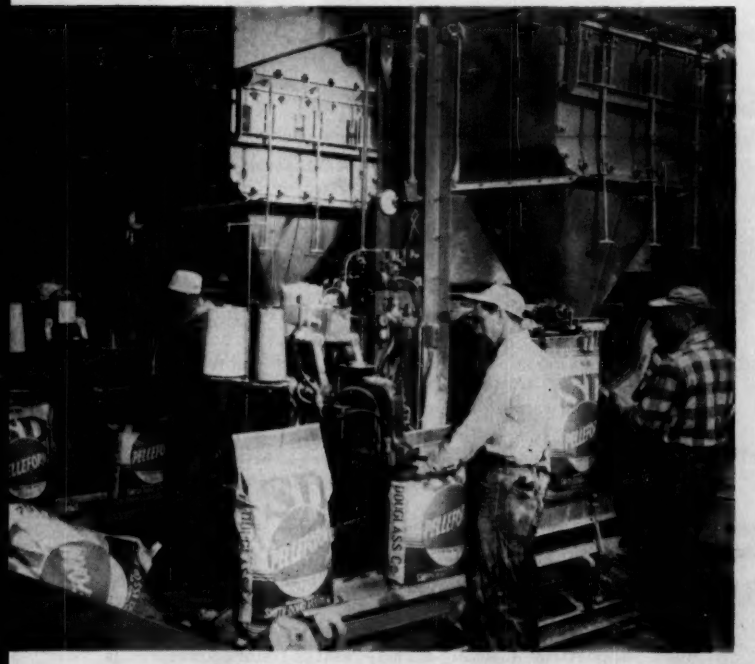
(Concluded on p. 96)



Steel drums collect solids discharged from a dryer. Generally of lighter gage than their liquid-containing counterparts, the drums are particularly valuable for rugged shipping and outside storage.



Burlap bags are sometimes used in export service—here, for fertilizer for an ally.

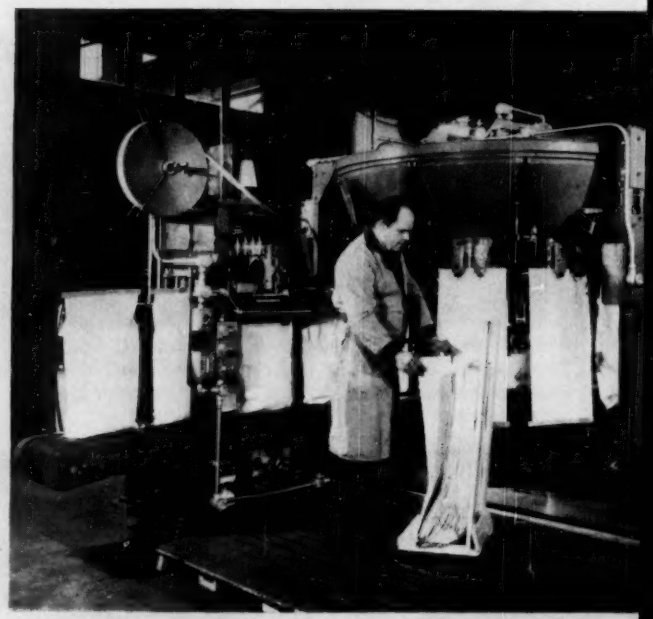


Multiwall paper bags, like steel drums, contain a large proportion of shipped, packaged chemicals. Operation of filling and closure by sewing, shown above, is fast one.

Fiber drums, used for liquids, too, are used here for the solid magnesium trisilicate. Tough but light, the fiber containers are readily handled and stored by palletizing.

Although it's important to choose the right container for chemical products, another important step exists in the packaging function: Selecting measuring-and-filling devices

FILLING MULTIWALLS



Packaging equipment is the machinery that prepares the product for shipment. The bulk of this report has been concerned with the container itself. But here, briefly and by no means comprehensively, are examples of machines on which the filling, weighing, closing and other packaging operations are carried out.

To package solids in multiwall paper bags, for example, International Paper Co.'s Bagpak Division offers the Bagpaker (model AF) shown at right. Automatic net-weighing scales normally feed product to the 10-station rotating turret. Empty bags, manually placed on each station's spout, receive product which is then settled by side and bottom "slappers."

Requiring only one operator, the machine has automatic devices to prevent discharge of the product if a bag should not be inserted at a station.

As the filled bags are lowered off their spouts, bag tops are power-stretched and flattened for sewing. A straight conveyor carries bags past sewing station and, after closure, delivers them for further handling. The heavy-duty sewing head stitches $\frac{3}{8}$ in. from top of bag. If desired, reinforced closure using selvage tape is applied automatically.

The manufacturer recommends the machine for packaging free-flowing or semi-free-flowing products at high production rates. Operating speed of the machine—up to 25 bags per minute—is instantly adjustable by variable-speed drive. The unit will handle bags of 15-16-in. face width and 30-36-in. length.

Over-all height of the machine with automatic scales is about $16\frac{3}{4}$ ft. Floor area is slightly greater than 9 x 12-ft. Scales and hopper that feeds to turret are supported on floor above, or otherwise independently of turret.

Machine is powered by a 2-hp. TEFC motor for main turret drive, a 1-hp. TENV motor for settler drive (if used) and a $\frac{1}{2}$-hp. motor for the sewing machine.

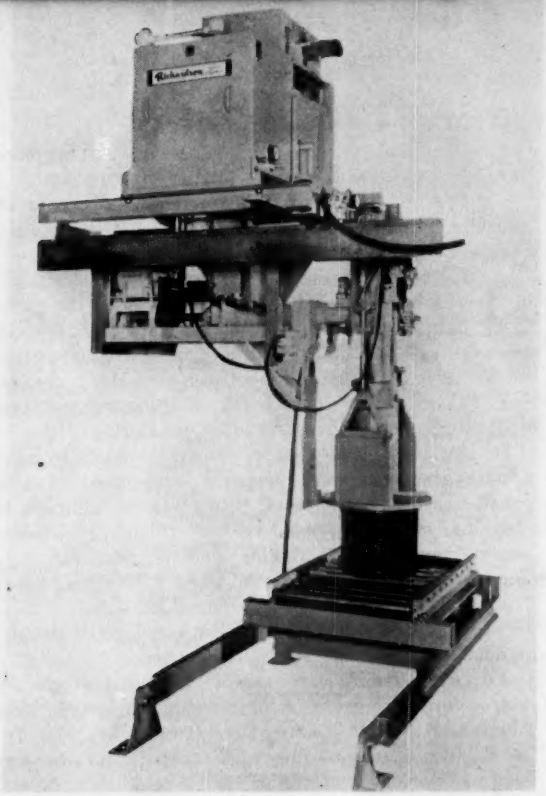
FILLS DRUM OR BAG

Another versatile solids packaging machine is the one shown at top right for filling drums or valve bags. Designed by Richardson Scale Co. for weighing and filling 600 lb./min. of material, the system will handle crystalline chemicals with densities up to 40 lb./cu. ft. for fine powders and 100 lb./cu. ft. for free-flowing materials.

An automatic scale weighs the solid and delivers it to a receiving hopper over a "Stoker" packer. Material is deaerated or compacted at this point and then conveyed by the packer directly to the filling tube.

For drums, the filling sequence is as follows: a frame supporting a heavy-duty gravity roller conveyor is raised by an air-operated lift actuated by foot pedal. In the raised position, the conveyor carries the drum last filled to a station where the lid is applied and brings the next empty drum up to the filling position. As conveyor returns to the depressed position, air-operated clamps automatically secure the empty drum.

As the filling tube descends, a drum cover at its base mates with the top of the drum to form a seal



that prevents escape of dust. The scale, set to weigh 1-4 times per drum, now weighs out the entire contents for the drum and delivers them into the receiving hopper.

Compacted by the Stoker packer, the material is conveyed to the filling tube from which it is deposited in the container. Material is shaken down into the drum by an air-operated, vibrating packer situated directly beneath the roller conveyor and equipped with extension bars that protrude through the spaces between the rollers.

Finally, the drum cover is raised, the roller conveyor returns to the raised position to advance the procession of drums and the cycle is repeated. Drums can be filled with from 90-400 lb. each. Their size may be 14-32 in. high and 13-20 in. in diameter.

Easily converted to bag-filling, the machine can maintain a rate of six 100-lb. bags per minute.

LIQUID-FILLS DRUMS

Liquids are measured by weight or by volume, and equipment for manual liquid-filling operations is available with either. When measuring by volume, of course, it's necessary to have a meter that can be adjusted (by setting temperature) for thermal expansion or contraction.

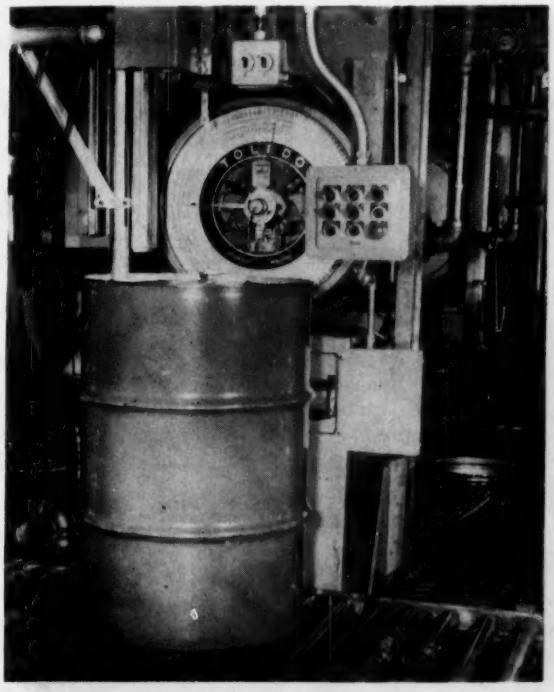
In the manual filling operations, one operator can roll an empty metal drum into position—perhaps on a platform scale—fill and close it and then remove it. One of the photographs on p. 88 shows this manual operation.

Increasingly popular are the automatic weighing and filling systems. Available for both solids and liquids packaging, these systems are integral parts of many automatically controlled processes today. Typical systems are described in detail in Considine ("Process Instruments and Controls Handbook," McGraw-Hill, New York, 1957, pp. 7-8 to 7-39).

Automatic drum-filling equipment for liquids is offered by several manufacturers, and it can be as fast and accurate as needed. One such type is the automatic drum filler for low viscosity liquids with foaming characteristics. Shown here is one such device made by Toledo Scale Corp.

Operator sets the unit for the desired net weight, and an automatic tare device compensates for weight of the empty drum. A filling ram lowers automatically into the drum and feeds the liquid with the nozzle always just beneath the rising surface to prevent any foaming.

Filling cycle is automatically cut off when desired net weight is reached. Net weight can be checked on the dial's outside circle of graduations and gross weight on the inner circle. Both fast and slow feeds give an accurate, automatic cut-off.



waterproof tape applied at juncture of bottom metal chime and sidewall.

There's one type of all-fiber drum on the market that is essentially straight-sided and has a nearly square cross-section. It was developed to conserve valuable cubage in export shipments.

Fiber drums, full or empty, can be stored in palletized units at least two or three tiers high. They are used extensively for domestic and export markets, can be readily decorated and, because of their low tare weight to net weight ratio, add a minimum to shipping costs.

Some other solids containers

Light-gauge steel drums with fully removable heads, friction lids and other special closures are also used by many for shipment of solids. They're particularly valuable where unusually rugged shipping conditions or outside storage are likely to be encountered.

Steel sheet (20-28 gauge) is used for the drums, which are generally corrugated to increase sidewall stiffness. Sized from about 10 gallons to about 55 gallons, these drums can be decorated by various techniques and lined with various resins.

For shipping powdered materials, fully removable-head steel pails of 1-10-gal. capacity and constructed of 24- or 26-gauge steel may also be used. They have lug- or lever-type covers that are equipped with flowed-in rubber gaskets and wire bail handles. Pails can be resin-lined as required.

Less frequently used units, valuable in specific cases, include corrugated fiberboard boxes with plastic film liners, all-plastic shipping bags, wide-mouth glass jars, bottles, tin cans and fiber canisters.

General container considerations

Regardless of the type of container ultimately selected, there are a few pertinent considerations:

• Except for those containers, such as multiwall bags, that are built to individual product specifications, containers generally are constructed with built-in outage. A 55-gal. steel drum can actually be filled with 55 gallons of product and still have room for expansion. This holds true for steel and fiber drums, pails, carboys and other containers that are made to a nominal capacity specification.

• If export shipments are to be made in any volume, care should be taken in establishing dimensions for the containers, to take full advantage of steamship conference regulations in calculating export cubage. Calculations involve dropping of fractional inches less than ½ inch, etc. A check with the conference involved will provide all the information.

• Unitized shipments of practically all types of containers are possible with available lift equipment, pallets, etc., and may save labor and containers.

• As far as possible before shipment of any product begins, consideration should be given to the packaging. This may call for a test program that involves drum-lining tests (for liquids), moisture-absorption tests (for solids), bag-filling tests, etc. Many organizations try to provide as much as six months of test work before commercial product packaging.

In any event, every effort should be made to have a packaging procedure properly established when a product is first distributed. The research facilities of container suppliers should be used whenever possible.

• Many products, solids and liquids, fall into hazardous classifications established by ICC and other regulatory agencies. These require that such products be packaged in specific containers, constructed in compliance with certain rigid specifications.

For steel drums, for example, special features required might be chime reinforcements, acid-type bung plugs and threads, heavy-gauge steel sheets, etc. It's in this area of container specification that the concept of "performance standards" should be established and used as sole criterion for a container's fitness.

Good packages are known by the following criteria:

1. They are safe—for the packer, shipper and user.
2. They comply with pertinent shipping regulations.
3. They provide the most economical distribution of product consistent with other requirements.

To order reprints of this 12-page CE report on Containers for Chemicals, circle number 166 on the Reader Service card. Reprint price is 50¢/copy

Meet the Author

THOMAS E. DOWLING, *a chemical engineer educated at Columbia University, joined American Cyanamid in 1945 to work on process development. He first entered the packaging field in 1952, directing the packaging research laboratory facilities at Stamford, Conn. Transferred to a staff packaging position in Cyanamid's New York City headquarters, Dowling is responsible for specifying and developing packages and packaging procedures for many of the company's products.*

An active member of the Bag Committee of the Packaging Institute, he is chairman of its Bag Closures Subcommittee and a member of the Policy Committee.

Since sewers are designed to operate only partially full, their capacity and flow velocity are unlike those of pipe under pressure, running full. In the graph at the right, discharge volume is based on a 5-ft.-diam. sewer.

How to Size Conduits for Storm Sewers

CHESMAN A. LEE, *Engineer, Evanston, Ill.*

In designing a chemical plant, the engineer must be able to size the underground sewer system for both sanitary sewage and storm water. The problem of determining how much rainfall to design for, and how to handle it in open runoff channels, was discussed by G. P. Fulton in a recent article (*Chem. Eng.*, May 2, 1960, p. 129). The basis of design for underground sewers is similar, but there are some special considerations that are dealt with here.

In general, sewers are designed to operate only partially full, which makes the design method quite different from the techniques familiar to the chemical engineer for handling design of pipes running full and under pressure. To avoid any possibility of backing up, a sanitary or combination sewer should always operate less than full. A sewer used only for storm water, as we shall see later, may be designed to operate full and overflowing under the worst conditions (although only partially full normally) and thus effect a considerable saving and some improvement in operation.

The Manning formula:

$$V = (1.486/n)R^{2/3}S^{1/2} \qquad (1)$$

is the one generally used for design of conduits running partially full. Here V = flow velocity, ft./sec.; n = a roughness coefficient ranging from 0.013 to 0.015; R = the hydraulic radius, ft. = flow cross-sectional area ÷ wetted perimeter; and S = hydraulic gradient (slope of the flow surface) in ft./ft.

Note that, for a circular pipe, the hydraulic radius is the same for a half circle as for a full circle. The factor n should be taken as 0.015 for sewers up to 24 in. in diameter. Perhaps it can be 0.013 above 24 in. but since storm sewers tend to silt up between storms, the writer is inclined to use 0.015 for all storm and combination sewers, regardless of size.

Examining the equation above, we see that the capacity of a sewer depends explicitly on the hydraulic radius and implicitly on the cross-sectional area of flow. Since the hydraulic radius depends both on the dimensions of the conduit and the conditions of flow, this obviously becomes a rather tricky problem in trial-and-error. The equation can be recast into a form that lends itself better to solution, as follows:

If A is the cross sectional area of flow in sq. ft., Q = flow quantity, cu. ft./sec., and $f = 1.486/n$, then $V = Q/A = f\,R^{2/3}\,S^{1/2}$ and

$$AR^{2/3} = Q/fS^{1/2} = K \qquad (2)$$

Eq. (2) is now in convenient shape for solution with the aid of the accompanying four tables. K is easily evaluated from Tables I and II. To go from this result to a suitable flow area and hydraulic radius, which will produce a conduit that will run less than full, now requires trial-and-error but is quickly accomplished with the aid of Tables III and IV. For easy calculation, all the tables contain the logarithms of the various quantities.

The derivation of Tables I to III is obvious, but Table IV requires some explanation. This table is based on a circle of 1 ft. radius or 2 ft. diameter. Table III provides conversion factors for other diameters. Table IV consists of certain factors related to segments of a circle, calculated for each 2½% of the total area of the circle. Not all the columns used in deriving the table appear in the final result shown here and, in fact, the table was derived in the inverse order but is used in the order shown.

In deriving the table, each decimal fraction of the area was multiplied by π to give A for the 2-ft.-diam. circle. Since all powers of r are equal to 1.0 for this circle, the column for A/r^2 represents this quantity. From a table of segmental functions, the corresponding values of arc/r were tabulated on the work sheet and also the values of A/r^2 ÷ arc/r = R/r.

This last comes about as follows: $A = \pi r^2$ and $R = \pi r^2/\text{arc}$ so $\pi r^2 r/(r^2 \text{ arc}) = (\pi r^2/\text{arc}) \div r = R/r$. Still on the work sheet, the values of R/r were raised to the $\frac{2}{3}$ power and finally multiplied by the already calculated values of A/r^2 to give a final column for $(AR^{2/3})/r^{8/3}$ that contains the essential relations among circle radius, hydraulic radius and circle area. Since the factors $(AR^{2/3})/r^{8/3}$ and A/r^2 are used in calculations, they appear in the table as logs.

Problem—This description may appear somewhat complex but running through a problem will show the use of the tables to be essentially simple. Take the case of a sewer with a gradient $S = 0.004$ and $n = 0.013$. If the flow is 300 gpm. or 0.67 cu. ft./sec. (gpm./449 = cu. ft./sec.), what will be a suitable sewer size and how full will it flow? Will the flow velocity be great enough?

Solution—Since $Q/fS^{1/2} = AR^{2/3}$ by Eq. (2), subtract the sum of the logs of f and $S^{1/2}$ (Tables I and II) from the log of Q to get log $AR^{2/3} = 8.9682\text{-}10$. Dividing $AR^{2/3}$ by $r^{8/3}$ will get us into Column 1 of Table IV. In Table III, try 8 in. diam., for which log $r^{8/3}$ is 8.7277-10. Then (8.9682-10) − (8.7277-10) = 0.2405 which is the log of $AR^2/r^{8/3}$. Enter Table IV at this value in the first column. Now, other values in this row correspond. Interpolating, we find the log of $A/r^2 = 0.3888$, while the decimal fraction of the pipe area that is filled in 0.779. Therefore, the pipe runs 78% full by area, which is acceptable.

Now, to investigate the flow velocity: From Table III, the log of r^2 for an 8-in. pipe is 9.0458-10. Adding this to the log of A/r^2 given above, we find log $A = 9.4346\text{-}10$. This subtracted from 9.8261-10, the log of $Q = 0.67$ cu. ft./sec., gives 0.3915, the log of V, whence $V = 2.47$ ft./sec.

Is this fast enough? It is right on the edge since storm sewers should have a V from 2.5 to 8 ft./sec. while sanitary sewers should flow above 1 ft./sec., and preferably above 2 ft./sec.

There are a few other points we should note. The diagram shows that maximum flow velocity occurs at 80% depth in the flow conduit, but maximum carrying capacity occurs at 95% depth. Sources for rainfall information and how to use it are covered in the Fulton article referred to above.

With a sewer intended for storm water only, there is no need for the hydraulic gradient to parallel the invert gradient (slope of conduit bottom). Intelligent undersizing in such a case can lead to quite a savings as noted above. Here, we go back to the original Eq. (1) and disregard the tables. We determine $R^{2/3}$ and V for the overfilled sewer, exactly as if the sewer were barely filled. We disregard the invert gradient and determine S as the hydraulic gradient.

Now, water will rise in the manholes in severe storms and we must check with our design storm to see if there is sufficient margin below grade. The fact that the sewer will be under pressure will be no cause for worry since the most severe loads will occur when the ground is saturated from earlier rain, and the pressures will balance.

Values of gradient Table I

S	log $S^{1/2}$
0.0020	8.6505
0.0025	8.6990
0.0030	8.7386
0.0035	8.7720
0.0040	8.8010
0.0045	8.8266
0.0050	8.8495
0.0055	8.8702
0.0060	8.8891

Values of n Table II

n	$f = \frac{1.486}{n}$	Log$f$
0.013	114	2.0581
0.014	106	2.0259
0.015	99	1.9959

Functions of pipe diameter—Table III

Diam., Inches	Log (r ft.)^2	Log (r ft.)$^{8/3}$	Area, Sq. Ft.
8	9.0458	8.7277	0.349
10	9.2396	8.9861	0.545
12	9.3979	9.1972	0.785
15	9.5918	9.4557	1.227
18	9.7501	9.6668	1.767
21	9.8840	9.8454	2.405
24	0.0000	0.0000	3.142
27	0.1022	0.1363	3.976
30	0.1938	0.2584	4.909
33	0.2766	0.3688	5.939
36	0.3522	0.4696	7.069
42	0.4861	0.6481	9.621
48	0.6021	0.8028	12.566
54	0.7044	0.9392	15.904
60	0.7959	1.0612	19.635
66	0.8787	1.1716	23.758
72	0.9542	1.2723	28.274

Functions of circular segment—Table IV

(Based on circle of radius = 1.0)

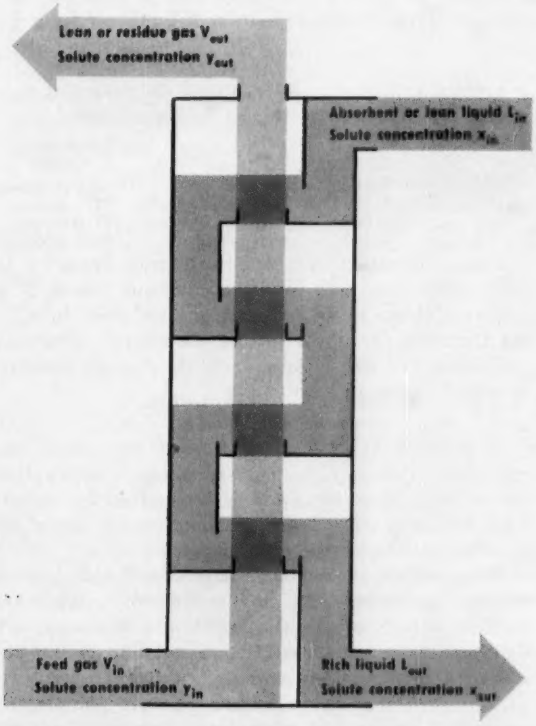
Log$\left(\frac{AR^{2/3}}{r^{8/3}}\right)$	Log$\left(\frac{A}{r^2}\right)$	Fract. Area	$\frac{h}{D}$
9.0209	9.4971	0.100	0.156
9.1587	9.5940	0.125	0.183
9.2708	9.6732	0.150	0.207
9.3654	9.7402	0.175	0.231
9.4469	9.7981	0.200	0.254
9.5188	9.8493	0.225	0.276
9.5828	9.8951	0.250	0.298
9.6404	9.9365	0.275	0.319
9.6930	9.9743	0.300	0.340
9.7409	0.0090	0.325	0.361
9.7854	0.0413	0.350	0.381
9.8264	0.0712	0.375	0.401
9.8647	0.0992	0.400	0.421
9.9004	0.1255	0.425	0.441
9.9341	0.1504	0.450	0.461
9.9657	0.1739	0.475	0.480
9.9954	0.1961	0.500	0.500
0.0239	0.2175	0.525	0.520
0.0503	0.2375	0.550	0.539
0.0758	0.2570	0.575	0.559
0.0996	0.2753	0.600	0.579
0.2931	0.1226	0.625	0.599
0.3101	0.1442	0.650	0.619
0.3265	0.1650	0.675	0.639
0.3422	0.1844	0.700	0.659
0.3574	0.2030	0.725	0.681
0.3722	0.2209	0.750	0.702
0.3864	0.2377	0.775	0.724
0.4002	0.2536	0.800	0.746
0.4136	0.2686	0.825	0.769
0.4265	0.2824	0.850	0.793
0.4392	0.2954	0.875	0.817
0.4513	0.3068	0.900	0.844
0.4633	0.3170	0.925	0.872
0.4748	0.3246	0.950	0.908
0.4861	0.3282	0.975	0.939
0.4972	0.2965	1.000	1.000

CE Refresher

Analyze Absorption in Gas Separations

JESSE COATES and BERNARD S. PRESSBURG
Louisiana State University

Material and energy balances, transfer rates and equilibrium govern the separation of material from gas to liquid phase during absorptions that occur in plate towers and packed columns.



Absorption is the most widely used method of separating gases. Where it can be used, it is usually preferable to other separation techniques because only moderate temperatures and pressures are necssary. Since the process tends to be reversible, recovery of components of the mixture and recycle of the absorbing medium are possible. Absorption may occur in a continuous manner with relatively simple equipment.

As one of the unit operations, absorption is a separation process in which a mixture of materials in the gaseous state is contacted with a liquid that preferentially dissolves one or more of the components. More frequently, the liquid absorbs the valuable component and the residual gas is discarded, such as in the absorption of hydrogen chloride in the Mannheim process. However, the operation is the same even if the solute is an unwanted impurity and the residual gas is the stream of interest. This operation is frequently referred to as scrubbing. An example is the removal of hydrogen sulfide or other odoriferous compounds before refinery waste gases are vented to the atmosphere.

In either case, the prime requisite is that an absorbent be available that will remove the designated component in a significantly higher proportion, relative to the nonsolutes, than its concentration in the feed gas. To be industrially practical, the absorbent should be relatively nonvolatile, not corrosive or toxic, and readily available at a reasonable price.

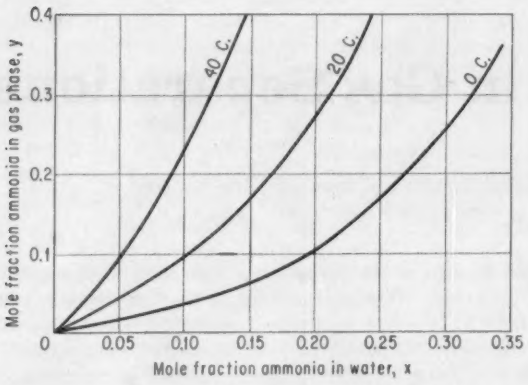
We can correctly generalize from these examples that all absorption separations are accomplished by the transfer of the solute from the gas phase into the liquid phase. To describe this process quantitatively, we must determine:

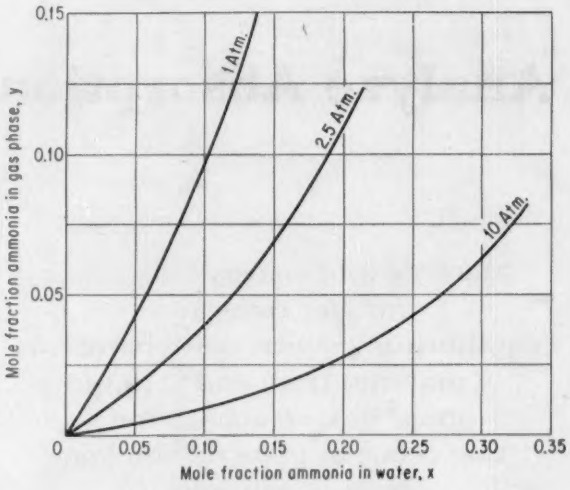
1. Material balance. The law of conservation of matter applies to the over-all system and to each material, around the entire absorber or any portion of it.

2. Energy balance. Likewise, the energy balance can be applied to the absorber in its entirety or to any part.

3. Equilibrium relationships. These establish the maximum transfer that can be effected in a specific situation.

To meet your authors, see *Chem. Eng.*, Sept. 5, 1960, p. 140.





Equilibrium diagram for the system ammonia-air-water at one atm. (above) and at 20 C. (right).—(Fig. 1)

4. Transfer rate. As in other transfer processes, the rate at which the solute moves from one phase to the other is determined as the quotient of potential and resistance.

The temperature and pressure for which an absorber is designed exert a big influence on the transfer. The equilibrium relationships that temperature and pressure establish determine the solute concentration in the absorbent and, thereby, the quantity of absorbent required to effect a specific absorption.

Although there are exceptions, countercurrent operation is preferred. Since the incoming gas has a higher solute concentration on entering than it does anywhere else in the absorber, the maximum concentration of solute in the liquid phase results when in equilibrium with it. While this maximum concentration is a theoretical value that cannot be reached in finite apparatus, it is a workable concept. The maximum concentration and the over-all material balance enable us to determine the ratio of absorbent to feed gas. In general, high pressures and low temperature minimize the absorbent requirements and also lead to smaller absorbers.

Problem 1—From a mixture containing 10% NH_3 and 90% air by volume, we recover 90% of the ammonia by absorption in water. Compare the minimum quantity of water required per 100 moles of mixture if the absorption is carried out at: (1) atmospheric pressure and 0 C., (2) atmospheric pressure and 20 C., (3) atmospheric pressure and 40 C., and (4) 2.5 atm. and 20 C.

On the basis of 100 moles of feed gas, the over-all material balance on the ammonia is: ammonia in feed gas plus ammonia in absorbent equals ammonia in residue gas plus ammonia in rich liquid, or:

$$10 + 0 = 1 + L_{min.}(x_{max.})$$

From Fig. 1 at $y = 0.1$, we read the values of $x_{max.}$ and calculate the quantities as tabulated below:

	$x_{max.}$	$L_{min.}$	Minimum Absorbent
(1)	0.194	46.5	37.5 moles
(2)	0.104	86.5	77.5 moles
(3)	0.053	170.0	161.0 moles
(4)	0.190	47.3	38.3 moles

Actual operation is carried out with from 10 to 100% more absorbent than the minimum values. The optimum excess is an economic matter since increasing the ratio results in smaller absorbers. Whatever absorbent-feed gas ratio is used, the over-all material balance is given by:

$$V_{N+1}y_{N+1} - V_1y_1 = L_Nx_N - L_0x_0 \qquad (1)$$

In Problem 1, 90% absorption of the solute was specified. However, in normal practice, absorption varies from 75 to 99% and is determined by operating conditions, concentration of solute in the absorbent and the economic size of apparatus.

If more than one solute is absorbed, the absorption of each cannot be specified independently. All other factors being equal, the relative recoveries are determined by their respective solubilities in the absorbent at the operating temperature and pressure.

Actually, the absorber may not operate isothermally as implied in our first example. Since there is a net flow of solute into the liquid and the absorption is accompanied by evolution of heat, temperature of the liquid tends to rise as it flow from top to bottom of the column. The over-all energy balance shows the extent of the temperature rise or, conversely, the heat

that must be removed to keep the outlet temperature under a prescribed maximum. The latter practice is known as side-stream cooling. By keeping the temperature low, less absorbent is needed and smaller absorbers result.

Problem 2—The composition of a typical wet gas leaving a well is:

N_2 + other inerts	3.0%
CH_4	59.5%
C_2H_6	19.8%
C_3H_8	12.1%
C_4H_{10}	4.7%
C_5H_{12} and higher	0.9%

The wet gas is to be contacted with a nonvolatile oil in the ratio of 60 moles of oil to 100 moles of gas, in order to recover 80% of the C_3H_8. Absorber operates at 250 psia. with the gas entering at 75 F. and the lean oil at 95 F. Since the oil is recirculated, assume that it contains 0.1% C_3H_8, 0.5% C_4H_{10} and 1.0% C_5H_{12}.

Determine (1) the quantity of heat to be removed if the outlet oil temperature is not to exceed 100 F, and (2) at what temperature the rich oil will leave the absorber if the heat is not removed.

Without extensive design calculations, the answers to this problem require an estimate of the absorption of the other hydrocarbons. For purposes of the preliminary heat balance, assume 5% of the methane, 40% of the ethane, 95% of the butane and almost 100% of the C_5 and higher hydrocarbons have been absorbed. On a basis of 100 moles of feed gas, the distribution of components and their enthalpies is then tabulated as:

	Feed Gas at 75 F.			Residue Gas at 100 F.		
	Moles	Enthalpy per Mole	Total Enthalpy	Moles	Enthalpy per Mole	Total Enthalpy
N_2	3.0	2,000	6,000	3.0	2,200	6,600
CH_4	59.5	2,340	139,000	56.5	2,550	144,100
C_2H_6	19.8	5,475	108,200	11.8	5,800	68,400
C_3H_8	12.1	8,020	97,000	2.4	8,450	20,400
C_4H_{10}	4.7	10,600	49,900	0.2	11,200	2,200
C_5H_{12}	0.9	12,900	11,600	0.1	16,800	1,700
	100.0		411,700	74.0		243,400
	Lean Oil at 95 F.			Rich Oil at 100 F.		
CH_4	.....	.....	.....	3.0	850	2,550
C_2H_6	.....	.....	.....	8.0	1,400	11,200
C_3H_8	0.06	1,610	100	9.74	1,750	17,050
C_4H_{10}	0.3	2,020	610	4.8	2,200	10,600
C_5H_{12}	0.6	2,400	1,440	1.4	2,600	3,600
Oil	59.04	5,350	316,000	59.04	5,790	342,200
	60.0		318,200	86.08		387,000

For this problem, the mixtures have been assumed to behave ideally, making the enthalpies additive. Therefore, if the rich oil is to be kept to a maximum of 100 F., the over-all enthalpy balance is:

$$411{,}700 + 318{,}200 = 243{,}400 + 387{,}000 + Q$$

Hence, the heat to be removed per 100 moles of feed gas is Q, which equals 99,500 Btu.

For the adiabatic case, Q is zero and the enthalpy of the rich oil is:

$$411{,}700 + 318{,}200 - 243{,}400 = 486{,}500 \text{ Btu.}$$

By calculations, this heat corresponds to a temperature of 117 F.

How to Size Absorbers

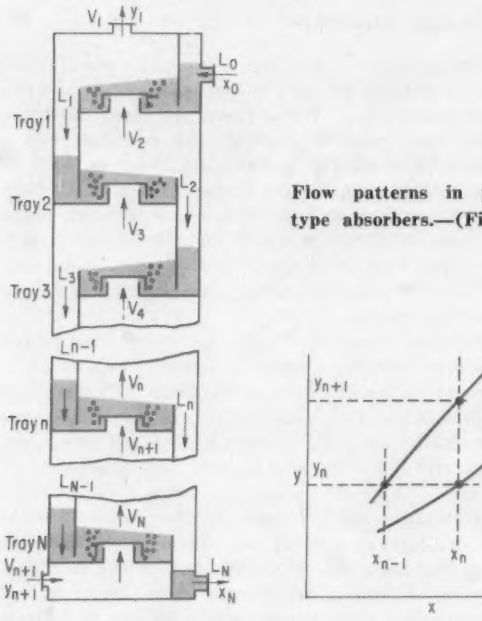
Before going into further detail with equilibrium and rates of transfer, let's look briefly at how absorbers are constructed. While there are many absorber designs, they may be divided into two categories: (1) those in which two streams are brought together and intimately contacted in a specific zone until they approach equilibrium and then are withdrawn separately and (2) those in which the phases are in contact continuously along the length of the column and in which there is no point where equilibrium is attained between the phases.

Bubble cap sieve plates and many other designs fall in the first category. Transfer occurs predominantly in the few inches of liquid on the tray through which the gas bubbles. To a lesser extent, transfer continues in the froth above the plate. Except for this zone, the gas and liquid follow separate paths and are not in contact. Fig. 2 shows this type schematically. Packed columns, spray towers, falling-film and similar units, in contrast, exhibit no such discontinuities in the transfer and a typical schematic is shown in Fig. 3.

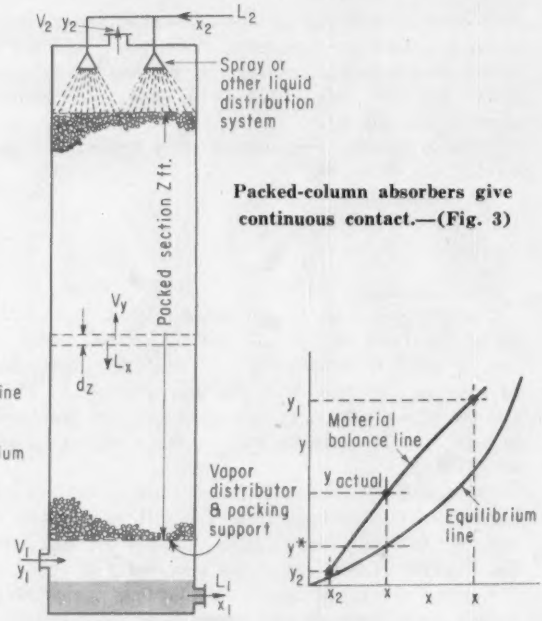
In view of these differences in absorbers, it is not surprising that their sizing usually follows two divergent paths. Equilibrium is the dominant consideration in the first category and the significant value to be evaluated is the number of theoretical plates (*NTP*) required to effect the separation. For the continuous contact type, the number of transfer units (*NTU*) and the corresponding height of a transfer unit (*HTU*) are more meaningful.

Nomenclature

A	Absorption factor equals L/VK, dimensionless.
A_e	Absorption factor, effective avg. for trays 1 to N.
f_A	Fractional absorption of component of incoming gas.
f_S	Fractional stripping of component of incoming liquid.
K	Equilibrium vaporization constant equals y^*/x or y/x^*.
L	Flow rate of liquid phase, moles/hr.
L_s	Flow rate of nonsolute portion of liquid phase, moles/hr.
l	Flow rate of each component in liquid phase.
m	Slope of equilibrium curve.
S	Stripping factor equals VK/L or $1/A$.
S_e	Stripping factor, effective avg. for trays 1 to N.
x	Mole fraction of solute in liquid phase.
x^*	Value of x in equilibrium with y.
y	Mole fraction of solute in vapor phase.
y^*	Value of y in equilibrium with x.
V	Flow rate of vapor phase, moles/hr.
V_s	Flow rate of nonsolute portion of vapor phase, moles/hr.
v	Flow rate of each component in vapor phase.
η	Tray efficiency.
Φ_A	Unabsorbed fraction of solute=$(1-f_A)$, defined by Eq. (6).
Φ_S	Fraction not stripped from incoming liquid=$(1-f_S)$, defined by Eq. (7).



Flow patterns in plate-type absorbers.—(Fig. 2)



Packed-column absorbers give continuous contact.—(Fig. 3)

Examine Available Sizing Methods

Numerous methods of determining the *NTP* have been proposed, of which four are used extensively. These are: (1) graphical solution, (2) plate-by-plate calculations, (3) Colburn's analytical equation and (4) absorption factor techniques. Each has its applications and limitations. Let's look at them.

Graphical determination of the *NTP* is simple to carry out and gives a clear picture of the changes that take place within the absorber. For all practical purposes, it is limited to binary mixtures and to operations that are substantially isothermal. For example, it applies when water is used to absorb low concentrations of carbon dioxide from air; but its use would not be satisfactory when propane and other components of a wet natural gas are absorbed simultaneously in oil from the incoming gas stream.

Where this method does apply, we can determine *NTP* by repetitive application of the operation shown in Fig. 2 for one theoretical plate. To do this, we must plot the equilibrium line for the system and the operating line as shown in Fig. 4. This is simplest if both lines are straight.

If the operating line is not straight, intermediate values for plotting it are obtained by substituting arbitrary values of the liquid phase concentration x in the material balance and solving for the corresponding vapor phase concentration y:

$$\frac{y}{1-y} = \frac{y_{N+1}}{1-y_{N+1}} + \frac{L_i}{V_i}\left[\frac{x}{(1-x)} - \frac{x_0}{(1-x_0)}\right] \quad (2)$$

For any value of x between the inlet x_0 and the outlet x_N, the operating line gives the actual concentration y that is passing it, and the equilibrium line gives y^* the concentration that would be in equilibrium with it. Accordingly, if we start on the operating line at the bottom of the column, a line drawn vertically to the equilibrium line determines x_N, y_N^* and a line drawn horizontally gets us back to the operating line at x_{N-1}, y_N^* which are the concentrations exactly one theoretical plate up the column. Fig. 4 shows that 2.75 such theoretical steps are required for the separation specified in Problem 1, using an absorbent rate L_0 that is 1.5 times the minimum.

Problem 3—With reference to Problem 1, for operation at 2.5 atm. and 20 C., find the number of theoretical plates required for the separation. Assume absorption is isothermal and that 57.5 moles of water will be used for every 100 moles of feed gas. Absorbent rate is essentially 1.5 times the minimum value.

From an over-all material balance of the process, we get:

$$100 + 57.5 = 91 + \text{bottom liquid}$$

Hence, the bottom liquid equals 66.5 moles and contains nine moles of NH_3 so that $x = 0.1354$. The ammonia balance around the top of absorber is:

$$Vy + (57.5)0 = 1 + Lx$$

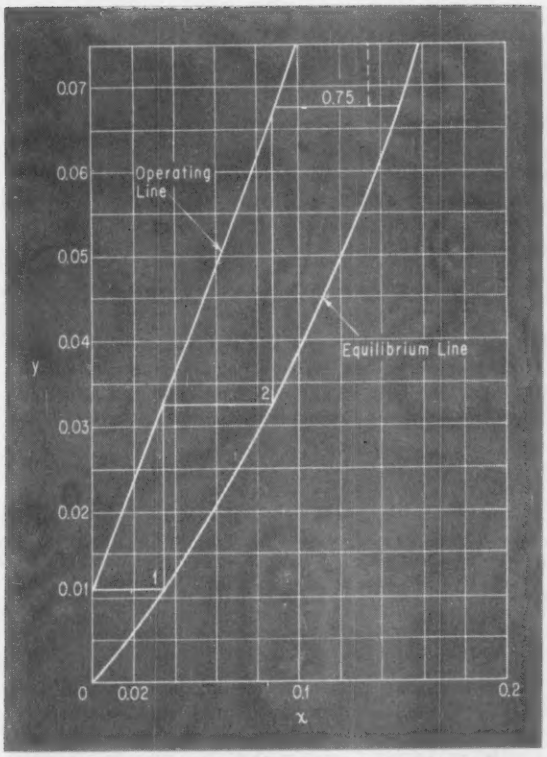


Fig. 4—For Problem 3, find number of theoretical plates.

$$\left(\frac{90}{1-y}\right)y = 1 + \left(\frac{57.5}{1-x}\right)x$$

Assuming values of x between 0 and 0.1354, we can calculate corresponding values of y as follows:

x	0	0.02	0.04	0.06	0.08	0.10	0.12	0.1354
y	0.0110	0.0236	0.0364	0.0493	0.0625	0.0759	0.09	0.10

Using these values, plot the operating line and determine the NTP as shown in Fig. 4.

Plate-by-Plate Calculations

When the energy balance shows a significant change in temperature for the column as a whole or for any one theoretical plate, or when the volatility of the absorbent or the solubility of the nonsolute gases is such that they appear in both phases, the NTP determined graphically may be considered a good approximation.

Exact solution requires the energy and material balances to be made from plate to plate. These usually require trial and error since no one quantity is absolutely constant as the solute-free gas and absorbent were assumed to be in Eq. (2). While techniques such as the Horton-Franklin relationships[5] guide the trial quantities, the procedure is tedious and becomes increasingly prohibitive as more components are added to the streams.

Short-Cut Methods Save Work

To avoid prohibitive calculations, several short cuts have been developed. The accuracy of their answers depends on the extent to which the actual conditions deviate from those assumed in the derivation.

For example, the Colburn[3] equation assumes constancy of the L/V ratio and the slope of the equilibrium line. These stipulations are more nearly satisfied when dilute concentrations are involved. The equation may be written:

$$NTP = \frac{\log\left[\left(\frac{y_{N+1} - mx_0}{y_1 - mx_0}\right)\left(1 - \frac{mV}{L}\right) + \frac{mV}{L}\right]}{\log\,(L/mV)} \qquad (3)$$

Eq. (3) may be applied to each component of a multicomponent system. Thus, it provides a good means of estimating the absorption of unspecified components by using the same NTP as found for the absorption of a specified key component. Graphical solution of this equation is available in various references.

Probably, the most widely used short cut is the Edmister[5] absorption factor. It is designed for use with any number of components and does not require that L or V be constant or that operation be isothermal. Should there be addition or removal of streams or heat, the method is still satisfactory by being applied to each section of the column separately.

Basically, the absorption factor method involves these equations:

• A material balance on each component.

$$v_1 = f_S L_0 + (1 - f_A) v_{N+1} \qquad (4)$$

• Definition of the absorption and stripping factors.

$$A_n = L_n/V_n K_n;\ S_n = 1/A_n = V_n K_n/L_n \qquad (5)$$

where n denotes any tray in the column and K the equilibrium constant which equals y/x. For normal operation and reasonable recovery of the solute, value of the absorption factor for the key component is in the range of 1.1 to 1.5.

• A relationship between the absorption factor, NTP and the absorption accomplished.

$$\Phi_A = 1 - f_A = \frac{A - 1}{A^{N+1} - 1} \qquad (6)$$

$$\Phi_S = 1 - f_S = \frac{S - 1}{S^{N+1} - 1} \qquad (7)$$

Eq. (6) is derived by writing the balance for one tray, combining it with the definition of the equilibrium constant and of the absorption or stripping factor as given in Eq. (5). Repetition of this for successive trays and simulation to eliminate all intermediate quantities leads to the useful forms shown. Actually, the result involves the product $A_1 A_2 \ldots A_N$ but reduces to the form shown if all A values are considered equal at an effective value, A_e. Edmister evaluates this as:

$$A_e = [A_N(A_1 + 1) + 0.25]^{0.5} - 0.50$$

Similarly, the S value for use in evaluating f_s is:

$$S_e = [S_1(S_N + 1) + 0.25]^{0.5} - 0.50$$

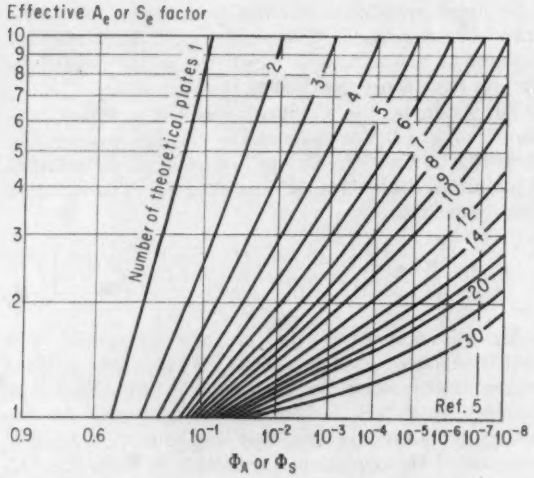


Chart solves equations for Edmister method.—(Fig. 5)

These equations require values for L_1, V_N, T_1 and T_N in addition to V_1 and L_N which are fixed by the specification for the separation. While determination of the first four quantities is trial and error, it can be carried out relatively quickly by use of charts such as shown in Fig. 5.

Problem 4—Use the Edmister method to determine the *NTP* for the adiabatic case of Problem 2.

To obtain a trial value of the absorption factors, assume $V_1 = 70$. The rich oil is then 90 moles per 100 moles feed, $V_{avg.}$ is 85 and $L_{avg.}$ is 75. Also estimating $T_{avg.} = 105$ F., these K and A values result:

	K	A
C_1	12.0	0.0735
C_2	2.02	0.436
C_3	0.84	1.05
C_4	0.264	3.34
C_5	0.099	8.90

Combining Eqs. (4), (6) and (7), we get the following relation for the key component C_3H_8:

$$2.42 = \Phi_A(12.1) + (1 - \Phi_S)0.06$$

Then, by using Fig. 5, we get, by trial and error, the *NTP* equal to 4.

Using *NTP* of 4, Fig. 5 and the above relation, we find for all other components these values:

	v_{top}		l_{bottom}
C_1	55.1		4.4
C_2	11.4		8.4
C_3	2.42		9.74
C_4	0.12		4.88
C_5	0.07		1.43
	N_2 3.00	Oil	59.04
Totals	72.1		87.89

Use the Horton-Franklin method[6] to evaluate V leaving the bottom tray and the temperature of the top tray.

$$\left(\frac{V_{top}}{V_{bottom}}\right)^{1/NTP} = \frac{V\ (leaving\ any\ tray)}{V\ (entering\ any\ tray)}$$

Substituting in the above equation, we find the vapor rate for the bottom tray equals 92.2 moles/hr. and for the second tray 78.4 moles/hr. Therefore, liquid from top tray is 66.3 moles/hr.

To estimate temperature of top tray, substitute in the following relation:

$$\frac{T_{top\ tray} - T_{absorbent}}{T_{bottom} - T_{absorbent}} = \frac{V_{2nd} - V_{residue\ gas}}{V_{feed} - V_{residue\ gas}}$$

which gives temperature of the top tray as 100 F.

Using these values, we can calculate new A and S values for the bottom and top trays and the effective values to use in the Edmister plots and equations. The results are:

	L	V	T
Bottom tray	87.9	92.2	118 F.
Top tray	66.3	72.1	100 F.

	Bottom Tray			Top Tray				
	K	A	S	K	A	S	A_e	S_e
C_1	12.7	0.075	....	11.8	0.0779	....	0.0751	....
C_2	2.16	0.44	....	1.97	0.466	....	0.446	....
C_3	0.95	1.00	1.00	0.80	1.15	0.869	1.005	0.95
C_4	0.269	3.54	0.283	0.245	3.74	0.268	3.59	0.275
C_5	0.121	7.85	0.128	0.091	10.2	0.100	8.85	0.105

Repeating our previous calculations, we find the *NTP* for the key component C_3H_8 is still approximately four. For all other components, we find the total vapor leaving the top is now 71.8 moles compared with 72.1 assumed and the total rich oil is 88.16 moles compared with 87.9 assumed.

As an additional check, we can verify that the rich-oil composition has a bubble point of 118 F. by computing the enthalpy balance for the components.

How to Find Actual Trays

All of these techniques determine the number of theoretical plates. To reduce this to an actual design requires a plate efficiency η that equals *NTP*/number of actual plates. It is in this efficiency term that the last consideration, the rate of mass transfer, enters.

For a given tray design and operating rates, the less resistance there is to transfer, the greater will be the quantity of solute transferred and the higher the tray efficiency. Values over 100% may be realized in some contact operations. In general, tray efficiency in absorbers is relatively low, about 20 to 50%, due to the resistance chargeable to the presence of non-absorbed gases.

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11 Quick Tests for Data Consistency

Visual methods proposed in this article will speed up the work of carrying out tests for thermodynamic consistency of experimental vapor-liquid equilibrium data.

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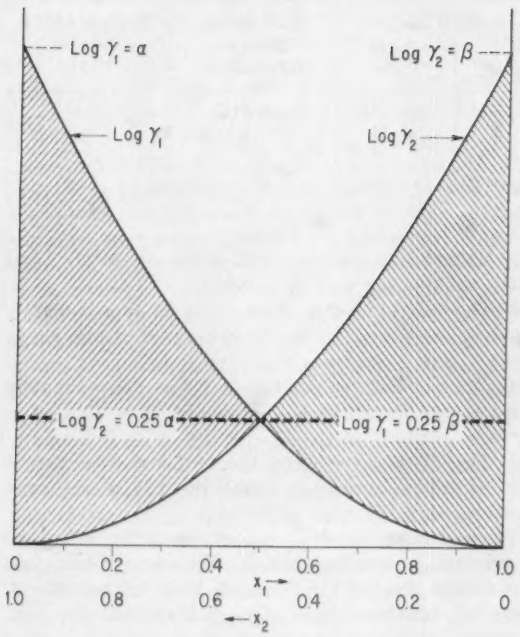


1. At $x_1 = 0.5$, $\log \gamma_1 \approx 0.25\beta$ and $\log \gamma_2 \approx 0.25\alpha$
2. At $x_1 = 0.25$, $\log \gamma_1 \approx (\log \gamma_2$ at $x_1 = 0.75)$
3. If $\alpha = \beta$, $(\log \gamma_1$ at $x_1 = x) = (\log \gamma_2$ at $x_1 = 1 - x)$ and, $(\log \gamma_1$ at $x_1 = 0.5) = (\log \gamma_2$ at $x_1 = 0.5) = 0.25\alpha = 0.25\beta$
4. If $\alpha > \beta$, $(\log \gamma_1$ at $x_1 = 0.5) < (\log \gamma_2$ at $x_1 = 0.5)$
5. If $\alpha < \beta$, $(\log \gamma_1$ at $x_1 = 0.5) > (\log \gamma_2$ at $x_1 = 0.5)$
6. $[(\log \gamma_1 - \log \gamma_2)$ at $x_1 = 0.2113] \approx [(\log \gamma_2 - \log \gamma_1)$ at $x_1 = 0.7887]$
7. Both log γ curves approach their zero values with a horizontal tangency.
8. The two areas bounded by the log γ curves and the $x_1 = 0$ and $x_1 = 1$ lines should be identical.
9. If there is a minimum or maximum on one of the log γ curves, there should be a corresponding minimum or maximum on the other curve at this composition.
10. If there is no maximum or minimum, both log γ curves should be on the same side of the log $\gamma = 0$ line.
11. At $x = 0.5$, the slopes of the log γ curves should be equal, but opposite in sign.

Tabulated at the left side of this page are 11 simple, visual tests that you can use to check on the thermodynamic consistency of experimental vapor-liquid equilibrium data—before the data are converted into distillation designs. In our discussion of these tests, we'll emphasize their applicability to binary non-electrolyte solutions.

The tests described in this article assume the use of the Gibbs-Duhem equation and the consideration of certain strategic compositions on a semi-logarithmic plot of activity coefficient γ vs. composition x. We suggest some rules-of-thumb that are easy to use and seem to be justified by observations on many systems.

Let's consider the Gibbs-Duhem equation in the following form:

$$x_1 \left(\frac{\partial \log \gamma_1}{\partial x_1} \right)_{p,T} + x_2 \left(\frac{\partial \log \gamma_2}{\partial x_1} \right)_{p,T} = 0 \qquad (1)$$

Although our discussion will be aimed at the liquid phase, the same approach applies to the vapor phase.

Strictly speaking, Eq. (1) may only be applied at constant temperature and constant pressure. However, the dependence of activity coefficient on pressure is very small, so it can be neglected over a moderate pressure range. We are justified in using Eq. (1) at isothermal conditions; at constant pressure, when the boiling-temperature intervals are small; or at constant pressure, when the activity coefficients are not functions of temperature.

These restrictions should be observed in the discussion that follows.

Identify Strategic Compositions

The strategic points we've selected are the liquid compositions $x_1 = 0$, 0.2113, 0.25, 0.5, 0.75, 0.7887 and 1.0. Articles by Carlson & Colburn and the book by Wilson & Ries have illustrated the significance of log γ values at $x_1 = 0.5$, using the van Laar and Margules forms of the integrated Gibbs-Duhem equation.

Values of activity coefficients at strategic compositions

	At $x_1 = 0.2113$ $x_2 = 0.7887$		0.25 0.75	0.5 0.5		0.75 0.75	0.7887 0.2113
		$\log \gamma_1 - \log \gamma_2$	$\log \gamma_1$	$\log \gamma_1$	$\log \gamma_2$	$\log \gamma_2$	$\log \gamma_2 - \log \gamma_1$
van Laar	$\alpha = \beta$	$0.577\alpha = 0.577\beta$	$0.563\alpha = 0.563\beta$	$0.25\alpha = 0.25\beta$	$0.25\alpha = 0.25\beta$	$0.563\alpha = 0.563\beta$	$0.577\alpha = 0.577\beta$
	$\alpha = 2\beta$	0.726β	0.72β	0.222β	0.222α	0.735β	0.75β
	$\alpha = 3\beta$	0.723β	0.75β	0.188β	0.188α	0.810β	0.823β
Margules	$\alpha = \beta$	$0.577\alpha = 0.577\beta$	$0.281(\alpha+\beta)$	$0.25\alpha = 0.25\beta$	$0.25\alpha = 0.25\beta$	$0.281(\alpha+\beta)$	$0.577\alpha = 0.577\beta$
	$\alpha = 2\beta$	0.866β	$0.281(\alpha+\beta)$	0.25β	0.25α	$0.281(\alpha+\beta)$	0.866β
	$\alpha = 3\beta$	1.154β	$0.281(\alpha+\beta)$	0.25β	0.25α	$0.281(\alpha+\beta)$	1.156β
Redlich-Kister	$\alpha = n\beta$ $n = 1,2,\ldots$	$0.577(B'' - 0.333D'')$	$0.563(B'' - 0.25D'')$	$0.25(\beta - D)$ $\beta > D$	$0.25(\alpha - D)$ $\alpha > D$	$0.563(B'' - 0.25D'')$	$0.577(B'' - 0.333D'')$

Nomenclature

A, B	Constants in the van Laar equation
A', B'	Constants in the Margules equation.
B'', C'', D''	Constants in the Redlich-Kister equation.
p	Absolute total pressure.
T	Equilibrium absolute temperature.
x	Composition, mole fraction in the liquid phase.
α	Value of $\log \gamma_1$ when $x_1 = 0$.
β	Value of $\log \gamma_2$ when $x_2 = 0$.

In our study, we've extended the compositions considered. Also, we include the Redlich-Kister form of the equation.

The integrated forms of the Gibbs-Duhem equation are usually shown as follows:

van Laar

$$\log \gamma_1 = \frac{A}{\left(1 + \frac{Ax_1}{Bx_2}\right)^2} \quad (2a)$$

$$\log \gamma_2 = \frac{B}{\left(1 + \frac{Bx_2}{Ax_1}\right)^2} \quad (2b)$$

Margules

$$\log \gamma_1 = (2B' - A')x_2^3 + 2(A' - B')x_2^2 \quad (3a)$$

$$\log \gamma_2 = (2A' - B')x_1^3 + 2(B' + A')x_1^2 \quad (3b)$$

Redlich-Kister

$$\log \gamma_1 = x_2^2[B'' + C''(3x_1 - x_2) + D''(x_1 - x_2)(5x_1 - x_2)] \quad (4a)$$

$$\log \gamma_2 = x_1^2[B'' + C''(x_1 - 3x_2) + D''(x_1 - x_2)(x_1 - 5x_2)] \quad (4b)$$

At infinite dilution, let $\log \gamma_1 = \alpha$ when $x_1 = 0$; and let $\log \gamma_2 = \beta$ when $x_2 = 0$. Then $\alpha = A$ and $\beta = B$ for the van Laar equation; $\alpha = A'$ and $\beta = B'$ for the Margules equation; and $\alpha = B'' - C'' + D''$ and $\beta = B'' + C'' + D''$ for the Redlich-Kister equations.

Evaluation of activity coefficients at the strategic liquid compositions using Eqs. (2), (3) and (4) are summarized in the table on this page.

Examining and graphing the tabulated values leads to these significant conclusions:

1. Value of $\log \gamma_1$ at $x_1 = 0.25$ is approximately equal to the value of $\log \gamma_2$ at $x_2 = 0.75$.

2. The value of $\log \gamma_1$ at $x_1 = 0.5$ is approximately equal to one-fourth of β, the end value of the $\log \gamma_2$ curve.

3. The value of $\log \gamma_2$ at $x_1 = 0.5$ is approximately equal to one-fourth of α, the end value of the $\log \gamma_1$ curve.

4. The distance between the two $\log \gamma$ curves at $x_1 = 0.2113$ approximately equals the distance between the two curves at $x_1 = 0.7887$.

These conclusions are reached when the ratio α/β is equal to or smaller than 3. The same conclusions may also be reached for β/α equal to or smaller than 3, since all equations used are symmetrical. In fact, examination of many actual values of α/β or β/α ratios shows that the values are seldom larger than 2. Therefore, these conditions may be used with assurance.

5. Furthermore, we can obtain from Eqs. (2), (3) and (4) the information that at $x_1 = 1$ the partial derivative of $\log \gamma_1$ with respect to x_1 is equal to zero; and at $x_1 = 0$, the partial derivative of $\log \gamma_2$ with respect to x_1 is also equal to zero.

This indicates that when a $\log \gamma$ curve of a component approaches the pure composition, the limiting slope is zero. On a $\log \gamma$ vs. x plot, the $\log \gamma$ curve approaches the ordinate value of $\log \gamma = 0$ with a horizontal tangent line. This simple condition is often overlooked in the literature of consistency tests.

6. Another significant property of the $\log \gamma$ curves at $x_1 = 0.5$ is that the slopes of both curves at this point are equal numerically, but opposite in sign.

7. For a set of consistent data, the shaded areas shown on the diagram at the beginning of this article should be equal in area.

We have applied these conclusions to a large number of experimental vapor-liquid equilibrium data, and suggest that the 11 quick tests listed on the previous page will prove useful for examining the thermodynamic consistency of experimental equilibrium data.

If you have been searching for a new method to investigate high-temperature gas-phase reactions, you should consider

Chemical Shock-Tube Research

VICTOR KEVORKIAN
Esso Research and Engineering Co.

An area of processing that so far has been virtually unexplored by chemical engineers is that of high-temperature (above 2,000 F.) gas-phase reactions. Because of quite formidable experimental difficulties, researchers heretofore have been unable to "poke around" in this field, although highly profitable and interesting reactions may be awaiting discovery. For example, endothermic reactions—those whose equilibria improve with increasing temperatures—should be carried out at the highest practical temperatures in order to attain the highest yields.

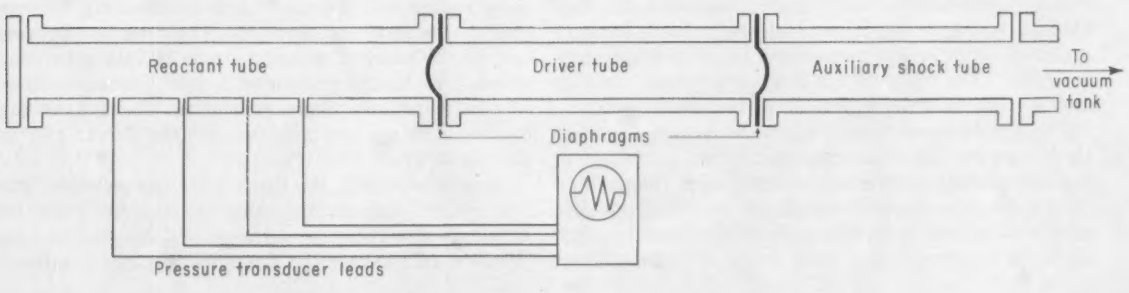
The difficulties of carrying out high-temperature research in conventional reactors are painfully apparent. First of all, the high temperatures may pose serious materials problems. It is also almost impossible to subject the reactants to controlled temperature-time conditions at high temperatures. Thus, if the kinetics of a reaction are studied in a conventional reactor at 3,500 F., how much more reaction (and side reaction) occurs during the long cooling process to temperatures below 1,000 F. where reaction rates are comparatively much slower? Finally, any gas phase studies at high temperatures would be marred by side reactions occurring on the reactor walls, because diffusivity, or ability of gas molecules to reach the reactor walls, is greatly enhanced at high temperatures.

The invention of the chemical shock-tube reactor by Hertzberg, Glick and Squire (U. S. Patent 2,832,665) has now swept away most of the barriers to the study of high-temperature chemistry. Although the ordinary shock tube was first described as long ago as 1899 by Vielle (Trans. Acad. Sc., Paris, Vol. 129, p. 1228) it was seldom used for chemicals research because of its "poor" and uncertain cooling, as we will show. However, when Hertzberg and his collaborators modified the shock tube so that it was able to subject a reactant gas to a single uniform high-temperature pulse and then cool the products quite rapidly, the rush of scientific prospectors to explore the high-temperature territory was on. This article is therefore presented in order to acquaint chemical engineers with this unique high-temperature short-time reactor, in case such a research tool is needed. The article will explain what a chemical shock tube is, how it operates, and the reaction conditions it is capable of attaining. The types of research that can be carried out in it will also be described, in order to help the chemical engineer decide if he also should be doing shock-tube studies.

Widespread Use of the Shock Tube

The list of academic and industrial research organizations engaged in shock-tube research is already a long one and is rapidly growing. Here is an admittedly incomplete one.

Schools—Massachusetts Institute of Technology;



High-temperature short-time reactions

Temperature, °F.	200 to 7,500
Pressure, psia.	30 to 1,500
Reaction time, milliseconds	0.1 to 6.0

California Institute of Technology; Brown University; Princeton University; University of Oklahoma; Lehigh; University of Michigan; University of Toronto, Canada; University of Tokyo, Japan; Imperial College, London, England; etc.

Industrial—Esso Research and Engineering; Shell Development, Sun Oil; Monsanto Chemical; Cornell Aeronautical Laboratory; Armour Research Foundation; Avco Research Laboratory; General Electric; National Advisory Committee for Aeronautics; Aberdeen Proving Ground; Naval Ordnance Laboratory; various aircraft and missile companies.

What Is a Shock Tube?

A chemical shock tube is a simple device in which gaseous reactants are heated very rapidly (in microseconds, 10^{-6} sec.) to high temperatures by shock waves. It consists of a pipe several inches in diameter, 10 to 100 ft. long, and a vacuum tank. The pipe is separated into two sections by a metal diaphragm. One section is charged with a high-pressure "driver" gas and the other contains reactant at a lower pressure ("driven" gas). The high-pressure section is separated from the evacuated tank by a second metal diaphragm. This reactor is schematically shown on the previous page. On page 110 is a photograph of the shock-tube reactor at the Esso Research and Engineering Laboratories, Linden, N. J.

When the diaphragm between driver and reactants is ruptured, the high-pressure driver gas rushes into the low-pressure reactant section at a supersonic velocity, generating a shock wave. This shock wave compresses and heats the reactants very rapidly, exactly as a fast-moving piston would. The temperature and pressure are further increased when the shock wave reflects from the end of the reactor.

Rapid cooling of the hot gases is accomplished by a cooling wave. This wave is generated when the diaphragm between the driver and the vacuum tank is ruptured a few milliseconds after the first diaphragm has burst. The wave speeds down the reactor, cooling the reactants at rates approaching 1×10^6 F./sec.

The simple shock tube, as opposed to the chemical shock tube just described, does not have a vacuum tank and consequently only has one diaphragm. Because of this, there are repeated reflections of the shock and expansion waves from the ends of the reactor. The repeated crisscrossing of these waves slow the cooling process and subject the gases to many temperature pulses. The cooling process is therefore uncertain because both the level and duration of these pulses cannot be easily and accurately calculated. The addition of the expansion tank of the chemical shock tube permits only one reflection of the shock wave, since the driver gas expands into the tank when the second diaphragm is ruptured. Consequently, the cooling process is very rapid and the temperature at which all of the reaction occurs can be readily calculated—things happen too fast inside the shock tube to measure temperatures.

Like Automobiles on a Crowded Highway

The physical picture of a shock wave may be visualized through the analogy of a lane of speeding automobiles on a superhighway. A driver sees a "caution" sign and suddenly applies his brakes. The driver of the following automobile must also abruptly reduce his speed before he can warn the driver of the automobile following him. A resulting "shock wave" travels back up the highway as each automobile slows down.

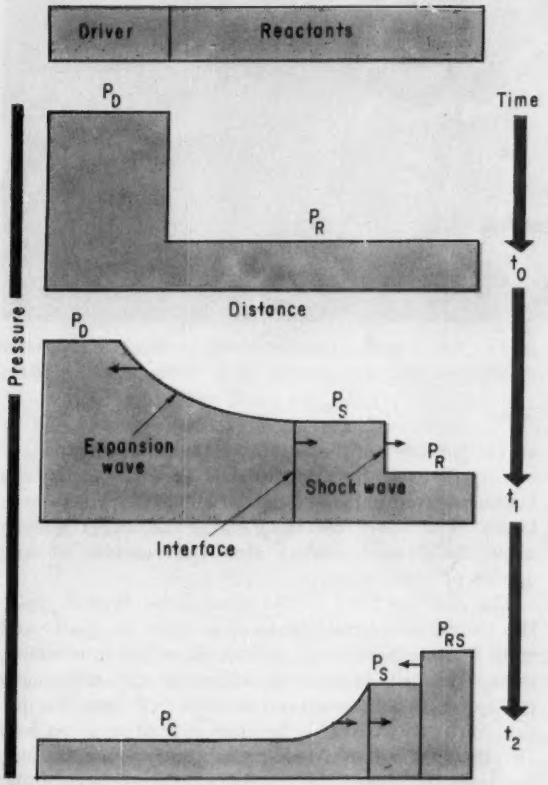
With the moving shock front serving as the frame of reference in the shock tube, the reactant molecules enter the front at a supersonic speed. This is because, relative to the shock tube, the shock wave is moving supersonically and the reactant molecules are initially at rest. However, if we use the shock front as the frame of reference, it appears to be stationary while the reactant molecules move supersonically toward it. As soon as the reactant molecules enter the shock front, their speeds are suddenly reduced to subsonic velocities, just as the speeding automobiles slowed down. This slowing of the reactant molecules upon entering the shock front causes a shock wave to propagate toward the end of the reactor.

The occurrence of high temperatures and pressures in the shock tube can be explained in terms of the changes of these variables with time, at various points in the reactor. Pressure-distance plots, taken after the diaphragm has been ruptured and the shock wave generated, show the resulting pressure changes caused by the shock wave.

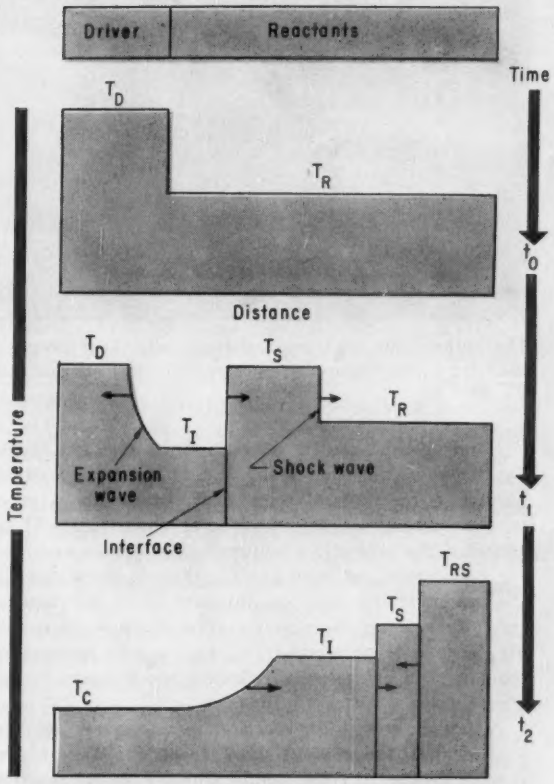
In Fig. 1, the shock tube is first shown with the diaphragm separating the two gases. At time t_0, the driver gas is at a pressure P_D, which is greater than the reactant pressure P_R.

At time t_1, after the diaphragm is ruptured, a shock wave rushes into the reactant gas, increasing its pressure to the shock pressure P_S. The interface between the driver gas and reactant gases is instantaneously accelerated to the right and follows the shock front at a lower velocity. An expansion wave simultaneously travels with acoustic velocity into the driver gas, reducing its pressure to P_S.

At a later time t_2 the shock wave has reflected from the end of the reactor, and the cooling wave has formed, upon rupture of the second diaphragm. The pressure of the reacting gases is increased further to



These graphs show how the pressure waves travel through the shock tube after the diaphragm is ruptured.—Fig. 1



Temperature-distance diagrams show how the shock waves heat the reactant gases to high temperatures.—Fig. 2

P_{RS} when the shock wave is reflected. After reflection, the shock front speeds back toward the oncoming interface which is still at shock pressure P_S.

The cooling wave reduces the driver pressure below that of the shock pressure to P_C. This strong wave now travels toward the reactant section at about twice the velocity of the interface. It catches up to the interface and rapidly reduces the pressure of the reacting gases.

The interface may be thought of as a piston that "drives" the reactant gas before it. There is, therefore, essentially no mixing of the driver gas and reactant gases. If a gas sample is removed at the end plate immediately after a run, it will contain no more than several volume percent of the driver gas.

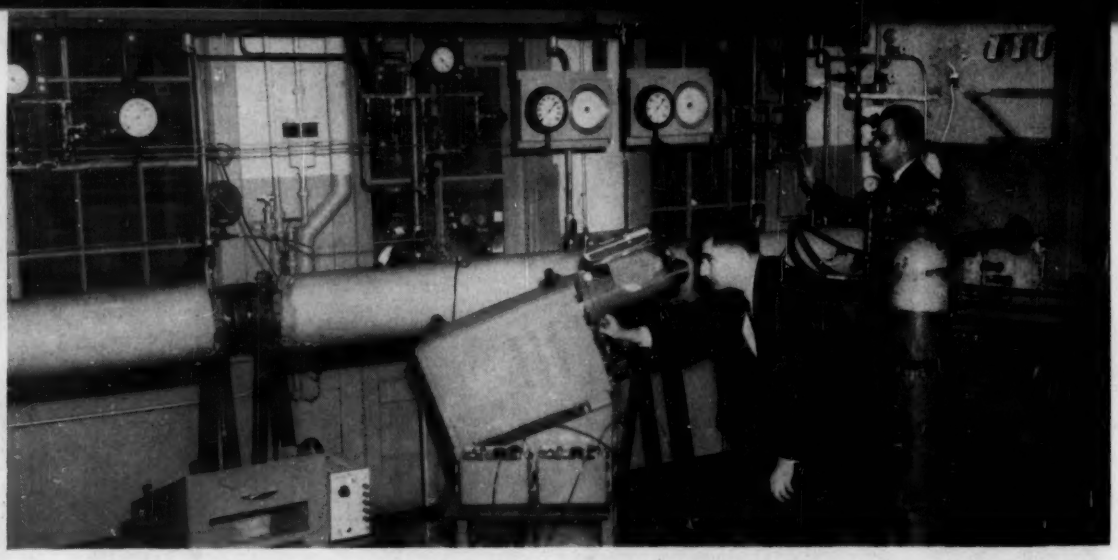
High Temperatures Are Attainable

Temperature-distance diagrams, Fig. 2, illustrate how shock waves heat the reactant gases to high temperatures. In the example shown in Fig. 2, the temperature of the driver gas T_D is greater than that of the reactant gas T_R before the diaphragm between driver and reactant sections is ruptured. The initial temperature of the driver gas may also, of course, be equal to that of the reactant gas. It so happens, however, that for a given pressure differential between the driver and reactant, the reflected shock temperature is greater when the driver gas is hotter than the reactant gas. This is, therefore, the case illustrated in Fig. 2.

At time t_1 after the diaphragm is ruptured, the temperature of the reactant gases between the shock front and interface is increased from T_R to shock temperature T_S. The expansion wave travels in the opposite direction and cools the driver gas from T_D to an intermediate value T_I.

At a later time t_2, reflection of both waves has occurred. Reflection of the shock wave causes an even further increase of reactant gas temperature, to T_{RS}. This is the temperature at which the reaction proceeds, because operating conditions are generally so chosen that the shock temperature T_S is too low to cause reaction.

The temperature caused by the reflected shock wave



The author, left, and his assistant make final preparations for a run. Cables from pressure transducers mounted in the shock tube are attached to the oscilloscope. At right is pipe leading to vacuum tank outside the window.

T_{22} is dependent on the velocity of the incident shock. T_{22} increases with increasing Mach number. The Mach number is the ratio of the velocity of the shock wave to the velocity of sound at local conditions. Thus, consider the case when helium is the driver gas, and air (considered an ideal gas for these calculations) is the reactant, and both are initially at room temperature. Increasing the velocity of a shock wave in the air from a Mach number of 4.6 to 6.45 causes the temperature behind the reflected shock wave to increase from 5,000 F to 10,000 F.

Although very high reaction temperatures may be used behind the reflected shock front, the walls of the reactor remain at room temperature. Because reaction times are of the order of several milliseconds, there is insufficient time for heat transfer from the hot gases to the reactor walls. This means that the reactor may not only be used repeatedly at high temperatures, where conventional reactors could not, but that the shock tube may be considered a "wall-less" reactor.

Residence time is so short that the reacting molecules don't have the opportunity to diffuse to the walls. Thus, the number of collisions of these molecules with the walls of the shock tube is negligible in comparison with the mutual collisions in the gas phase.

Because of the short times involved, then, the shock tube gets around the two serious limitations to the use of conventional reactors for high-temperature research —safety, and confusing side reactions occurring on the walls. On the other hand, the very short reaction time also prevents the reaction temperature from being accurately measured, because the response time of such devices is too long. Reaction temperatures have to be calculated from equations based on the measured velocity of the incident shock wave. These equations are derived from the laws of conservation of mass, momentum and energy across the wave fronts. Shock-wave velocity is determined by pressure transducers mounted in the shock tube. Their pressure pickup signals, caused by arrival of the shock front, may be used to automatically start and stop a timer. Alternatively, the signals may also be displayed and timed on an oscilloscope and be automatically photographed.

Very fast reactions may be studied in the shock tube because of the high cooling rates and short residence times. The short residence time and rapid quench allow the investigator to stop the reaction at any degree of completion.

The reaction time in the shock tube depends upon the time needed for the cooling wave to reach and cross the interface. Once it does, the reaction is almost instantaneously halted. By adjusting (1) the length ratio of reactant to driver sections, (2) the thermodynamics and physical properties of the two gases, and (3) the time between rupture of the two diaphragms, reaction time may be controlled fairly accurately, within several tenths of a millisecond. An example of adjusting physical properties is blending a small amount of high molecular weight gas such as nitrogen with a low molecular weight driver such as hydrogen.

How Could You Use the Shock Tube?

Chances are that you are a chemical engineer working in process development, research or design. You would therefore be most interested in the possible use of the shock tube to improve processes, to obtain physico-chemical properties of gases at high temperatures or, probably most important of all, to uncover new reactions which might be commercially exploited. The application of the shock tube toward these ends will, therefore, be treated most extensively.

In Chemistry—Many important processes involve endothermic reactions. These are reactions, as mentioned previously, whose equilibrium yields improve with increasing temperatures. Examples of such reactions are thermal cracking, nitrogen fixation and hydrogen cyanide production. To improve these processes, it would be worthwhile to do some research at elevated temperatures. The point to be determined, of course, is whether the yield of the desired product continuously increases with increasing temperature, or whether undesirable side reactions become important and cause the yield to fall of. If this is the case then,

perhaps there is a higher optimum reaction temperature at which the product yield is a maximum.

For studying reaction mechanisms at elevated temperatures, the chemical shock tube probably has no peer. It is important to make such studies because the mechanism of a reaction at high temperatures may be markedly different from that at low temperatures. This might mean that a process, unprofitable at normal temperatures, may be profitable at higher ones.

To illustrate this point, let us consider the production of ethane by the pyrolysis of methane. Let us assume that the over-all process is made up of a series of free radical, nonchain reactions, the first of which is the formation of methylene radicals, CH_2. Methylene radicals then might react with more of the feed in the second reaction to produce methyl radicals, CH_3, which might be thought of as an unstable intermediate. Ethane is then formed when two methyl radicals react with each other. The general reaction sequence is:

Primary Rupture:

$$CH_4 \rightarrow CH_2 + H_2 \quad (1)$$

$$CH_3 + CH_4 \rightarrow 2CH_3 \quad (2)$$

$$2CH_3 \rightarrow C_2H_6 \quad (3)$$

Termination:

$$CH_2 + H_2 \rightarrow CH_4 \quad (4)$$

or

$$CH_2 + H_2 \rightarrow CH_3 + H \quad (5)$$

At "normal" temperatures, it is found that high yields of ethane cannot be obtained because methylene radicals are removed from the reaction sequence by H_2 via the termination step, (4). Since the methylene radicals are, therefore, prevented from making CH_3 radicals, high yields of ethane, consequently, cannot be obtained and it is said that the pyrolysis of methane is self-inhibited.

Now what happens if the temperature is increased a moderate amount? Because the decomposition of methane is inhibited, its conversion remains low. The yield of ethane then begins to decrease, because its rate of decomposition accelerates with temperature. Summarizing up to this point, then, we see that the yield of the product, which we would like to maximize, falls off with increasing temperature, and yet we advocate shock-tube research at very high temperatures!

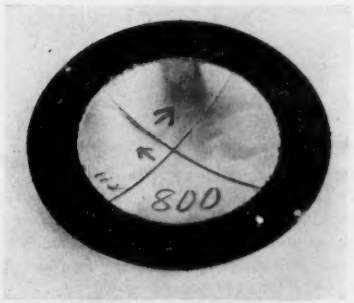
The reason for saying this is that the mechanism of the reaction may be quite different at elevated temperatures. Suppose that there is another possible termination step, (5), whose rate is much slower than that of (4) at "normal" temperatures, but whose activation energy is greater. Thus, at considerably higher temperatures in the shock tube, the rate of (5) will become faster than (4), so that (4) no longer will predominate. H_2, therefore, which is an inhibitor at normal temperatures because it slows the formation of methyl radicals is not one at very high temperatures. Hydrogen reacts in step (5) to form CH_3, which goes on to form ethane in reaction (3).

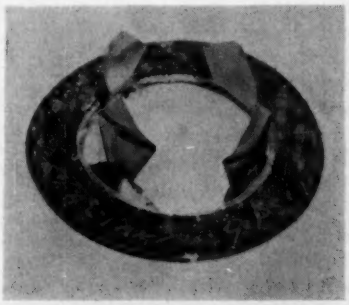
Another feature of the shock tube—its behavior as a reactor without walls—may be used in other mechanism studies to unequivocally determine if any part of a gas phase reaction occurs on surfaces. The normal procedure to determine this is by packing a reactor to varying degrees and measuring the reaction rate to learn if it is affected as the surface-to-volume ratio of the reactor is changed. However, if the reaction is both initiated and terminated on walls, such a kinetic study might lead to spurious results.

Because of the very fast reaction times, reactions in the shock tube essentially occur entirely in the gas phase. They have no heterogeneous components. Hence, if the kinetics of a reaction that is initiated on walls is studied in the shock tube, its rate will be found to be much slower than when studied at the same temperature in a conventional reactor. Conversely, the rate of a wall-terminated reaction will be much faster in the shock tube. A reaction that is both wall initiated and terminated would be slower in the shock tube.

Still another feature of the shock tube may be exploited in chemical research. This is the rapid quench inherent in the shock tube because of its high cooling rate, which approaches 10^6 F./sec. Because of this, it is possible to cool a reacting mixture so rapidly that the gas composition is "frozen." The cooled products will very closely approximate the hot reacting mixture behind the reflected shock wave.

The rapid quench of the shock tube permits the isolation and identification of unstable intermediates that are formed when either one or several components





Diaphragm at left, shown before installation, is scribed so that the plunger will strike the intersection of the cuts. Diaphragm at right, after rupture, shows the four quadrants which flatten against the tube.

react at high temperatures. Thus, in this way, diacetylene was shown to be formed before carbon when acetylene was pyrolyzed in the shock tube. Another example of this is the possible isolation of hydroperoxides when hydrocarbons are partially oxidized. The identification of species present in a reaction system at high temperatures may also be conveniently accomplished by a spectrograph attached to the shock tube near the end plate.

The rapid cooling of the shock tube may thus be used to elucidate reaction mechanisms, both through kinetic studies and the identification of unstable intermediates. It is, of course, important to have insight into the mechanism of a reaction so that the yields of desired products may be maximized while those of undesired ones are kept low.

A most important asset of the chemical shock tube is that it permits meaningful high-temperature chemistry studies for the first time. The experimeter may, therefore, come across reactions which do not "go" at temperatures below 2,000 F. When gases are heated to very high temperatures, the molecules may reach highly excited states. Such high-energy species may react in quite an unexpected way, leading to valuable products that could not be attained under normal conditions.

Aerodynamics and Physics—The shock tube up to now has found its chief application in aerodynamics and physics research. Because of the high Mach numbers (up to 20) of the incident shock waves, conditions simulating those encountered by missiles in space may be created in the shock tube. This permits evaluation of such diverse items as missile nose cones and building designs that can withstand shock waves resulting from H-bomb and A-bomb blasts.

In the realm of physics, the shock tube has been used for important studies of high-temperature phenomena in gases. Included in these studies are measurements of physico-chemical properties, dissociation energies, relaxation phenomena, and the different species existing in ionized and excited gases.

A Continuous Shock Tube?

So far, some of the assets of shock-tube research have been mentioned, so the reader could determine if he might also be profitably spending some time in this area. Nothing was said about the possibility of discovering a reaction in the shock tube that could not be commercially exploited because of the high-temperature limitations of conventional reactors. The philosophy behind this approach is that if something of sufficient interest is discovered at high temperatures, then a commercial reactor can be designed to run the reaction on a continuous basis.

Several reactors now being developed, or on the drawing boards, may be suitable for high-temperature processing. Hertzberg, Glick and Squire (U. S. Patent 2,832,666) for example, have patented a continuous shock tube. It looks like a Gatling gun with several tubes mounted in a barrel-shaped bundle. This bundle rotates around its major axis. When the ends of a particular tube pass the openings in the end manifolds, driver gas rushes in, causing a shock wave. When the tube rotates past another opening, the driver gas is exhausted, the product gases are removed and the tube is cooled by admitting and removing another gas. Making each tube rotate past openings through which gases may be admitted and removed makes the shock tube continuous by replacing the metal diaphragms of the one-shot chemical shock tube. Thus, although each tube of the continuous shock tube is a "batch" reactor, the entire assemblage is a continuous one, with feed and cooled product streams continuously entering and leaving it.

The chemical shock tube is a high-temperature, short-time reactor. As such, it is an ideal research tool for studying high-temperature chemistry under controlled conditions. A simple one might be built by the reader or a complete system bought from such companies as Autoclave Engineers or American Hollow Boring Co. The reader should now be able to decide if he should be doing shock-tube research, and should be sufficiently familiar with its principles to follow shock-tube research reported in the literature.

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Meet the Author

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What Engineers Should Know About Patents and Claims

To the average engineer, patents may not seem important—at least, not to him personally. But he may be willing to concede that perhaps they are of some importance to the research scientist who in the course of his professional career will become an inventor.

In many respects, patents are more important to the engineer than they will ever be to the research man because they are not only a source of information on past engineering development but are also indicative of present engineering trends. Furthermore, much of the information reported in patents is not available in any other publication.

FLOYD TRIMBLE
Attorney, Oklahoma City, Okla.

A highly important feature of patents that the average engineer probably is not aware of is that an unexpired patent may represent valuable property rights. This is important because any use of that patent without the owner's permission constitutes a trespass or an encroachment or, in patent parlance, an infringement upon the owner's rights for which the infringer may be held liable for a large sum of money. This statement seems very broad; it was so intended.

The important question, in fact, the only question, is: Did the defendant's actions constitute infringement? It is unimportant—or, as the lawyers say, it is immaterial and irrelevant—that the defendant was using the invention for himself only, had no intention of infringing the patent or did not even know that the patent, which he is now charged with infringing, existed.

To avoid infringement, therefore, you must not only be alert to the existence of patents but also able to understand them, so that you can form an accurate opinion as to whether or not certain contemplated actions will constitute infringement.

Since a company must rely upon its employees' advice for guidance in patent matters, it follows that the person who can give accurate advice will be a valuable employee. This is important to the engineer because when a company is considering a change, that proposed change will probably be submitted to the engineers first for their evaluation. Consequently, the engineer who understands patents is in a good position to prevent his company from infringing an adversely held patent. Thus, patent knowledge becomes an important engineering tool.

Engineers will no doubt find patents and, more particularly, the claims, very difficult reading. In form, each claim is a single sentence that may contain several hundred words. Patent lawyers also employ a professional jargon all their own that serves to mystify the casual reader even further. It is, therefore, little wonder that engineers find claims difficult reading. And they are in good company because no less an authority than the United States Supreme Court has, in effect, stated that claims drafting is the most difficult of all legal writings.

Referring to legal writings in general, that astute authority on the American legal system, Mr. Dooley, remarked "A statute which reads like a stone wall to the layman becomes, for a corporation lawyer, a triumphal arch." Mr. Dooley's comment is far from unfounded. Jeremy Bentham, an English philosopher and jurist, noted that the lawyers in the office of the Clerk of the Pells—an accounting office in the English Exchequer—kept the money accounts in Roman numerals as late as 1800. The difficulties of addition and multiplication in Roman numerals are surpassed only by the incomprehensibility of such accounts to any but the Clerk of the Pells.

Claim language today often possesses this same degree of difficulty and incomprehensibility. But instead of Roman numerals, the modern claim draftsman relies on such words and phrases as "comprising," "consisting of," "consisting essentially of," "means for," "plurality," "predetermined" and, of course, that overworked word "said," without which practically no legal document could be written. Since these terms are used frequently by patent lawyers—almost every claim will contain at least one of them—the engineer should become familiar with their meaning in patents.

"Comprising" includes everything specifically mentioned in the claim, but does not exclude the presence of other ingredients or steps not mentioned. In other words, "comprising" is inclusive but not necessarily exclusive.

"Consisting of" includes only those ingredients or steps specifically mentioned. This phrase is both inclusive and exclusive.

"Essentially" means something essential or indispensably necessary.

"Consisting essentially of" includes those ingredients or steps specifically mentioned that are indispensably necessary, but does not necessarily exclude unspecified ingredients or steps not affecting the basic and novel characteristics of the composition or process.

"Means for" is the method or mechanism, including known equivelants, for accomplishing the desired objective.

"Plurality" means more than one.

"Predetermined" means that which has been previously determined.

"Said" means before-mentioned and has the same force as "aforesaid."

Unfamiliar terms are not meant to confuse the engineer but are employed because over the years they have acquired a legal certainty of meaning. A patent, and especially the claims, must be stated in exact terms that will withstand the scrutiny of the courts during the life of the patent. The statutes require that the claim clearly distinguish what is claimed from what went before in the art, and clearly delineate that which is foreclosed from the public. Futhermore, a claim must be capable of being separately read. In brief, it must point out and distinctly claim an identifiable invention. The requirement as to its capability of being separately read often makes a long claim mandatory.

Although patents and patent claims are difficult to read, the task is not insurmountable. We can greatly simplify it by considering the statutory requirements in reference to patents, followed by a careful analysis of prior art and the invention.

Rule 51 of the Rules of Practice, United States Patent Office, defines a complete patent application as comprising: a petition, a specification, an oath, a drawing when necessary and the prescribed filing fee. For the purpose of this discussion, we will confine our interest to the specification.

Patent statutes require that the specification contain a written description of the invention, and of the manner and process of making and using it, in such full, clear and concise terms as to enable any person skilled in the art to which it pertains, or with which it is most closely connected, to make and use the same. It should also set forth the best method contemplated by the inventor for carrying out his invention. The statutes state further that the specification shall conclude with one or more claims particularly pointing out and distinctly claiming that which the applicant regards as his invention.

From the foregoing, it appears that the term "specification" includes the claim or claims, although many authorities contend that this is not correct. But other authorities, as well as the Patent Office, say the term "specification" includes the claims.

All authorities agree that the claims are a definition of the invention, pointing out in legal parlance the "metes and bounds" of the invention, making them the most important part of the patent. Thus, it follows that if you do not understand the claims, you will fail to comprehend the full significance of the patent. Conversely, if you do understand the claims, you will understand the patent.

Drafting Claims

There are two reasons for describing claim drafting. Claims are the most important part of the specification and patent lawyers have found that the best way to write the specification, in fact it is the only satisfactory method, is to write the claims before anything else.

As an illustrative example, we will take a typical invention concerned with a process for preparing a water-soluble sulfonate having improved odor, color and detergency properties compared with sulfonates prepared by prior art processes. In brief, the invention comprises the preparation and purification of polyolefins that are subsequently used in alkylating an aromatic hydrocarbon. The resulting alkyl aryl hydrocarbons are purified and an appropriate fraction is sulfonated. In the final step, the sulfonic acid is neutralized to yield the desired sulfonate.

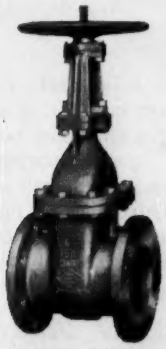
A study of the prior art discloses that the invention resides in two of the process steps, all other steps of the process are old. Both these steps concern the purification of the intermediate components. One relates to the purification of the crude polyolefins and the other to the purification of the alkyl aryl hydrocarbon.

We may write the several steps of the process in tabular form, as follows:

1. Preparation of the polyolefin.
   a. Polymerization.
   b. Fractionation.
2. Purification of the polyolefin.
3. Preparation of the alkyl aryl hydrocarbon.
   a. Condensation.
   b. Sludge separation.
4. Purification of the alkyl aryl hydrocarbon.
   a. Acid treatment.
   b. Caustic wash.
   c. Fractionation.
5. Sulfonation.
6. Neutralization.

Since the invention resides only in steps 2 and 4, we will describe these steps in greater detail, using information available to the inventor, before we make any attempt to write claims.

The polyolefin obtained from the first step is not a pure compound but is a mixture comprising desirable and undesirable isomers having the structures $R'' CH = CHR'''$ and $RR' C = CH_2$, respectively,



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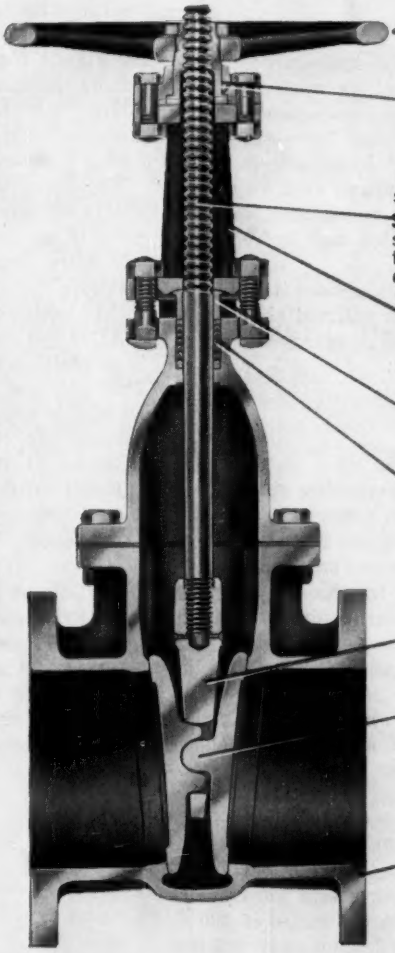

WHEEL of high strength malleable iron designed for firm grip and easy operation.

YOKE BUSHING, easily renewable. Made of bronze, for ideal thread engagement with stainless steel spindle, to prevent seizing or galling of spindle threads. Bushing of stainless steel is optional.

SPINDLE has long thread bearing surfaces with correct lead for easy, tight closing. Screws into wedge carrier, then secured by a stainless steel pin.

YOKE BONNET has liberal space between yoke arms for easy access to packing box. Precision machined flange face assures uniform contact with gasket for a tight body-bonnet joint.

GLAND consists of two pieces — gland flange and gland follower — eliminates binding of follower in case gland bolts are tightened unevenly.

PACKING of Chevron-type Teflon in large packing box prevents leakage. Only a minimum load is required on gland, extending service life of packing.

WEDGE CARRIER connects wedge to spindle and raises or lowers it. Husky in size to stand any operating strains.

SPLIT WEDGE is the ball-and-socket design which automatically adjusts to the tapered seating surfaces for positive shutoff. The discs, revolving freely in the wedge carrier, produce a self-cleaning action on seating surfaces and reduce possibility of galling and seizing.

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wherein the R's represent alkyl radicals that may be the same or different.

As a result of his research, our inventor has discovered that treatment of the mixture with a Friedel-Crafts catalyst at an elevated temperature will condense and render insoluble the undesirable isomers. A suitable quantity of catalyst varies from 1 to 10% or more, based on the weight of the mixture. Temperature and time of the reaction may be varied from 25 to 150 C. and from 24 to ½ hr. While this treatment converts the undesirable isomers to an insoluble form that permits easy removal by filtration, it has little effect upon the desirable isomers.

Finally, we obtain a satisfactory fraction of desirable isomers by taking the portion that boils between 120 and 240 C.

Extraction of color and odor precursors with sulfuric acid purifies the alkyl aryl hydrocarbon fraction in step 4. After extraction, we wash the alkyl aryl hydrocarbon with an alkali to remove any remaining sulfuric acid and then subject it to fractional distillation to remove unreacted hydrocarbons. The concentration and amount of sulfuric acid may vary from 80 to 100% and 1 to 25%, respectively, depending on the quantity of crude alkyl aryl hydrocarbon in the mixture.

We can now write the claim easily since it is merely a recitation of the process steps outlined above, connected together with functional language to define an operative process as follows:

A Typical Claim

"A process for the production of a water-soluble sulfonate which comprises: polymerizing an olefin in the presence of a polymerization catalyst to polymers having the structure $RR'C = CH_2$ and $R''CH = CHR'''$ wherein the Rs are alkyl radicals and may be the same, removing the catalyst sludge, fractionally distilling said polymers to obtain a fraction boiling within the range of 120 C. to 240 C., treating said fraction with a Friedel-Crafts catalyst at a temperature within the range of 25 C. to 150 C. for a period of time which may vary from 24 to ½ hours whereby the polymers having the structure $RR'C = CH_2$ are condensed, allowing the resulting mixtures to separate into two layers, a lower layer comprising the catalyst sludge and the condensed polymers, and an upper layer comprising polymers having the structure $R''CH = CHR'''$, removing the lower layer, fractionaly distilling the upper layer comprising said polymers to obtain a fraction boiling within the range of 120 C. to 240 C., reacting said second mentioned fraction with an aromatic hydrocarbon in the presence of an alkylation catalyst to form an alkyl aryl hydrocarbon, allowing the resulting mixture to separate into two layers, removing the lower layer comprising the catalyst sludge, extracting the upper layer comprising the alkyl hydrocarbon with 1 to 25 parts of sulfuric acid having a concentration varying from 80 to 100 per cent per 100 parts of the alkyl aryl hydrocarbon, allowing the resulting mixture to separate into two layers, removing the lower layer comprising sulfuric acid having dissolved therein the color and odor precursors, washing the upper layer comprising the alkyl aryl hydrocarbon with an aqueous alkali solution, recovering the alkyl aryl hydrocarbon from said washed upper layer by fractional distillation, subjecting said alkyl hydrocarbon to a sulfonating agent under sulfonating conditions, and then neutralizing the resulting sulfonic acid to form the desired sulfonate."

Write Additional Claims

After writing a claim, such as the above, that defines the invention in broad terms, the inventor should be queried as to preferred ranges or limits thus providing a basis for additional claims. This line of questioning reveals that practically any Friedel-Crafts catalyst may be used, though $AlCl_3$ is preferred. A preferred temperature range varies from 30 to 75 C. with a reaction period varying from 1 to 3 hr.

You can write additional claims in which you substitute the preferred ranges for the suitable ranges given in the first claim. If you wish, you may write still more claims listing specific olefins and specific catalysts that have been used or that you are sure will be satisfactory.

After you have written all the claims, you will be in a position to write the rest of the specification. This will now be a relatively simple procedure since all that is required is to write a description that will support the claims and give one or more specific examples to illustrate the invention.

Rule 77 of the Rules of Practice of the United States Patent Office specifies that the following order of arrangement should be observed in framing the specification:

a. Title of the invention.
b. Brief summary of the invention.
c. If there are drawings, brief description of the several views of the drawing.
d. Detailed description.
e. Claim or claims.
f. Signature.

Meet the Author

FLOYD TRIMBLE *was formerly manager of patent prosecution for Continental Oil Co. and is now in private practice as a patent attorney. Mr. Trimble is well qualified to write on chemical patents since he has an M.S. in chemistry as well as his LL. B. He has been in patent law for sixteen years and his experience embraces all phases of this wide field. He is a member of several state bar associations, the American Patent Law Association and the American Chemical Society.*

Four-Way Valves Provide Foolproof Piping System

When there are several tanks connected to the same supply line, operator errors and valve leaks can lead to difficulty. The system shown here is foolproof, relatively inexpensive and it salvages liquid lost by other methods.

★ **Winner of the July Contest by**
Dick E. Milholland
Chemical Manufacturing Supervisor, S. C. Johnson & Son, Racine, Wis.

A problem that often confronts chemical engineers is how to pump liquid into one of a series of tanks through a single pipeline without the danger of leaking into the wrong tank.

The simplest and most direct route to such an arrangement is also the most likely to cause trouble. That is the use of a header with a valve and stub line to each tank—which presents the threat of valve leakage, as well as operator error.

One of the most common solutions to this problem is to connect any one of the tanks to the header, as needed, using a hose that can be disconnected as shown in Fig. 1. This solves the problems of leakage and operator error, but has several disadvantages of its own that can be summarized as:

- Cost of installation is high.
- Large hoses are hard to handle.
- When a liquid is being run into any one tank, such as No. 2, it is possible to trap some of it in pockets in the lines to the other tanks.
- Unless the disconnect fittings on the hose are of the type provided with check valves (which have a high pressure drop), some of the liquid will spill when the hose is disconnected.

Fig. 2 shows how four-way lubricated plug valves can be used in a hoseless disconnect system that eliminates these disadvantages. The sketch shows liquid being run into the No. 2 tank of a series of three. However, there is no limit to the number of tanks that can be connected to the header in this way.

Compared with the hose method, the four-way valve system has the following advantages:

- It is lower in cost.
- The valves are easy to operate and may even be equipped with mechanical operating devices.
- The system prevents any spillage during disconnection.
- All liquid is pumped into the correct tank since there are no pockets in the pipeline.
- Valve leakage can be detected immediately and cured by tightening the lubrication fitting.

Fig. 2 shows the liquid passing through Valve 1 and Valve 2 into Tank 2. If any valve should leak, the liquid will drain into a container for salvage. There is no chance of leaking uphill into the wrong tank, since all the idle tanks are automatically connected to the drain. When Tank 2 is shut off by turning Valve 2 through a quarter turn, part of the pipeline will drain into the salvage container. Flushing the liquid with a cheap solvent such as water, or use of check valves in the tank lines, will keep the amount of salvage liquid to a minimum.

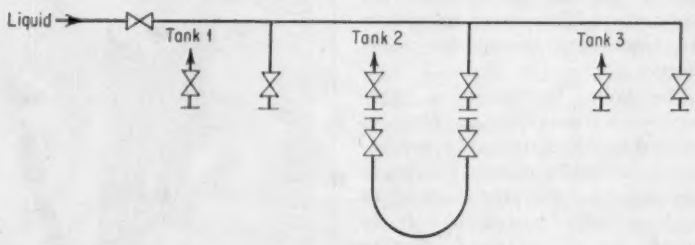


Fig. 1—Pipe header, using hose to connect to any one of three tanks, can solve leakage and operator-error problems but brings problems of its own.

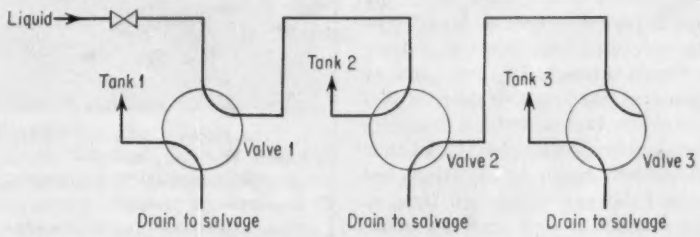
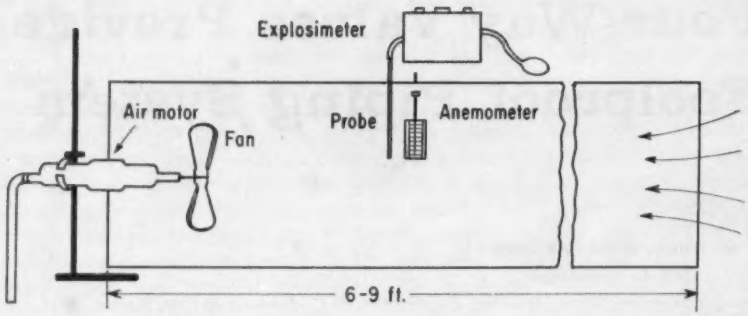


Fig. 2—Using four-way lubricated plug valves connected to the header, to the tanks and to salvage containers is simple, leakproof and low in cost.



"SNIFFER" LOCATES LEAKS

J. GILADI
Chemical Engineer
Israel Institute of Technology, Haifa.

Every refinery is concerned with evaporation losses that, it has been estimated, may run as high as 2% of the throughput. The lost fractions are light-end gasoline and LPG and the first step in reducing their loss is to discover where and to what extent the losses occur.

Illustrated here is a device which I constructed for the Consolidated Refinery Ltd., in Haifa, for making such a loss survey. As might be expected, packing leaks in pumps and valves are among the worst offenders.

The device consists of a light-gage pipe containing a fan, an anemometer and the probe connection to an explosimeter. A suitable size range for the pipe is about 18 in. in diameter and 6 to 9 ft. in length. An air motor—for safety and speed variability—is used to drive the fan that draws the vapors through the pipe.

In use, the suction end of the pipe is placed as near as possible to the suspected leak location and air is drawn through. The explosimeter measures the concentration of hydrocarbon vapors and the anemometer measures air volocity and thus shows how much hydrocarbon has passed through in a given time, as the product of pipe area, air velocity and vapor content.

A high air velocity ensures better scavenging of the vapors but, of course, leads to low vapor concentrations so that a compromise, determined experimentally, is best.

Big Lift For a Heavy Wrench

Fred Parsley, who is a rigger foreman at Carbide's Texas City plant, shows the dolly-mounted pneumatic impact wrench developed by his crew for handling the big nuts that secure the lower head of the methanol converter. It formerly took two men merely to hold the wrench in place. Now, the wrench is rolled under the converter, connected to the air line, then lifted with little effort by pushing down on the handle to encase one of the nuts.

No. 41: COMPUTERS FOR COST ESTIMATING

At the fourth annual meeting of the American Assn. of Cost Engineers, in Houston this past June, several interesting ideas were presented in papers and workshops. One of the most intriguing was a report by three M. W. Kellogg Co. engineers on application of digital computers to capital cost estimating.

In an era when many other basic problems of engineering are being tackled through computer use, this report, sponsored by the estimating methods committee of the metropolitan New York section of AACE, casts light on possibilities for cost engineers.

We'll confine our remarks to those points in the report that seemed most interesting, i.e., those directly concerned with cost estimating rather than those having to do with computers themselves. (A report on the latter was published, *Chem.Eng.*, Sept. 7, 1959, pp. 127-144.)

▶ **Computer Advantages**—Computers, as is becoming well-known, force engineers to regard problems carefully and precisely. Cited as a corollary: computer cost estimating offers consistent, precise application of a carefully preplanned procedure, with virtual elimination of error.

Cited, too, are economies. Computer use generally reduces cost of application of a procedure and calendar-time requirements for the estimate.

These economies are particularly important in the way that Kellogg proposes using its extensive computer programming. The engineer-constructor firm plans to eventually integrate three now-separate phases: process design, mechanical design and cost estimating. Of course, it's the opinion of estimators that the first two steps usually cut into the time that they are supposed to have in the final step.

A third advantage is ability to handle the same work load with fewer personnel or larger work load with the same number of personnel. Kellogg's experience has been that estimating work has risen to 2-3 times former noncomputer loads because management now demands more.

▶ **Disadvantages, Too**—The committee report characterizes two problems arising from computer use. One is that a tendency may arise among estimators to use a computer blindly and gradually to lose job judgment and interpretive skills.

The other problem is that personnel tend to become insecure about their work in relation to the computer and uncertain about computer capabilities.

Though not trivial, these problems can probably be solved by proper training and enlarged definition of personnel responsibility. Once estimators are familiar with computer capabilities (and limitations), they gain greater pride in work from the higher volume of better estimates they can turn out, using the machine as a tool.

▶ **Data Go In**—We'll skip over the problems of programming. Important as they are, they're pretty general in all computer applications. But there are three groups of input data that are necessary for computer estimating: job or problem data, semiconstant data and constant data.

Within a given estimate, preparation of job data is the heaviest work. These data, specific only to the particular job, must be gathered and processed for each estimate.

Importance of this step was emphasized by the committee when they showed that by reversing unit costs of conduit and fixtures in a lighting estimate, personnel preparing a computer run produced a $1 million cost rather than the $15 thousand expected! Computer use requires great care, with more emphasis on accuracy, in this data preparation stage.

Price and discount information and labor productivity fall into the semiconstant data group. Since such data are used over and over, accuracy is important, but subsequent work on these data are in the nature of updating rather than collecting.

Questioned about this updating, the panel said that the task was eased considerably by applying appropriate cost indexes to the stored information.

Final data group is the constant data—those which are primarily scientific and engineering constants and factors. Once in the program, these are no longer a worry.

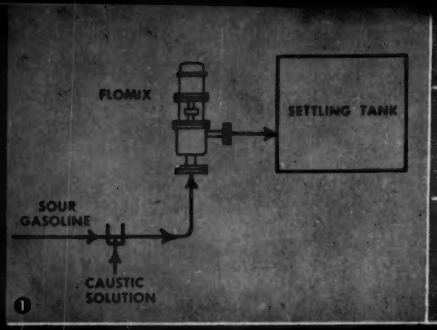
▶ **Using the Computer**—Input, for the cost estimating phase, is material quantities derived from the mechanical design phase or from any other source such as final design drawings or bills of material. Material is summarized or costed (including fabrication and labor) by computer program.

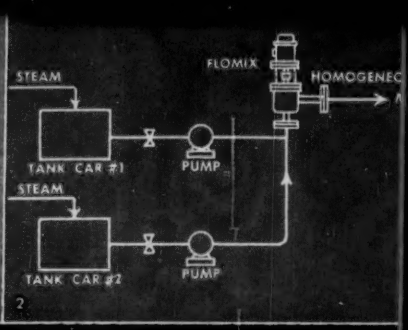
An example given by the committee was estimating piping materials. Input data for the problem are number of valves by size and type, and approximated length of pipe by size and specification. Data are determined from flowsheet and plot plan.

Output from the computer provides, among about 50 items, the following: adjusted number of valves by size and type, adjusted length of pipe by size and type, weight of fittings by size, number of flanges by size and rating.

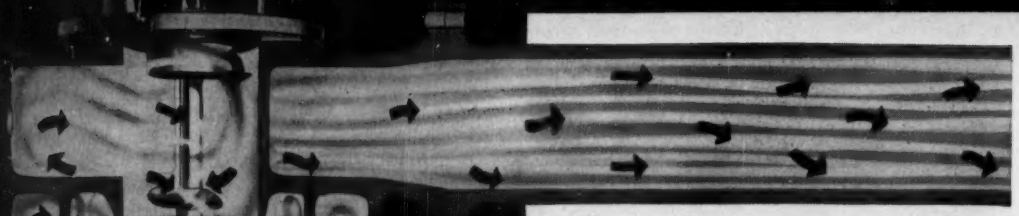
This estimate also provides dollar value of pipe, valves, flanges and fittings plus total material cost; dollar cost of shop-fabricated piping; labor man-hours required for erection, by material classification, and total man-hours.

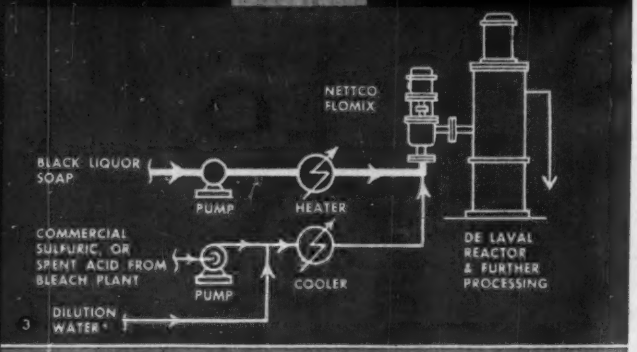
On the computer used for this program (a Burroughs 205), an average estimate (material costs about $250,000) required 45 min. to produce output as compared with four man-weeks without the machine.

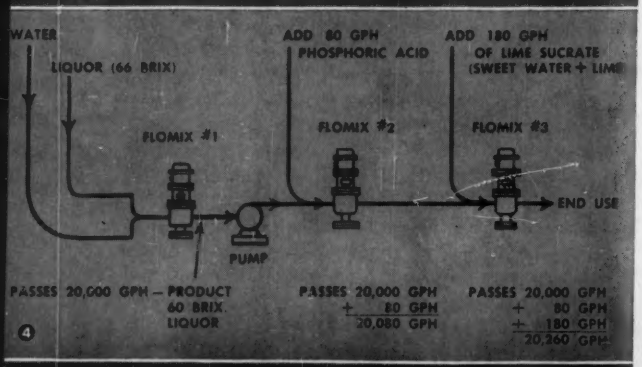


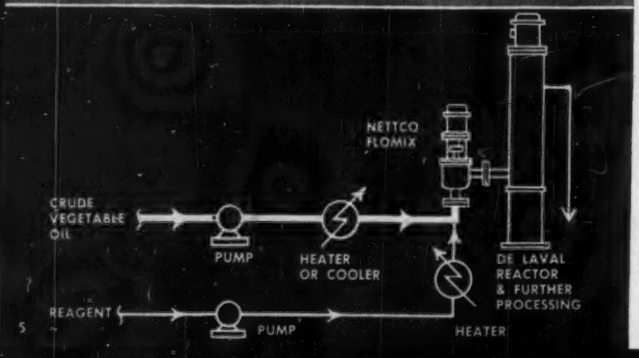


Improved Processing through Engineered Agitation









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R_x for Better Steam Economy: Condensate Return Systems

R. J. LUNDRIGAN
Cochrane Corp., Philadelphia, Pa.

In any steam processing system, large or small, heat transfer efficiency can be no better than the means of controlling the escape of condensed steam and noncondensable gases. Poor or erratic heat transfer resulting from inadequate condensate drainage not only slows production and wastes fuel but may seriously affect product quality.

An ideal condensate drainage system will: (1) sustain temperature and pressure head corresponding to the steam pressure; (2) remove condensate, gases and air; and (3) prevent escape of steam that has not given up its latent heat to the process.

Mere drainage of the condensate is not enough to ensure the most efficient rate of heat transfer. There must be some steam flow to create turbulence and "scour" gas and condensate films that tend to form insulating layers on the walls of heat transfer surfaces. This requires venting of steam somewhat in excess of the condensation rate—the actual amount varying from startup conditions, when it should be large, to a relatively small quantity under operating conditions.

While it can be difficult to find the proper balance among the many requirements for optimum condensate handling, it is seldom necessary to accept inefficient heat transfer as an attendant evil.

When properly selected, conventional nonreturn steam traps can provide satisfactory solutions in many cases. A wide range of designs of bucket, float, thermostatic and thermodynamic traps is available. These are the nonreturn types that discharge condensate at considerably lower than steam operating pressure. (For a discussion of nonreturn steam traps, see "Banish Your Steam Trap Troubles," L. C. Campbell, *Chem. Eng.*, Jan. 1957, pp. 227-232.)

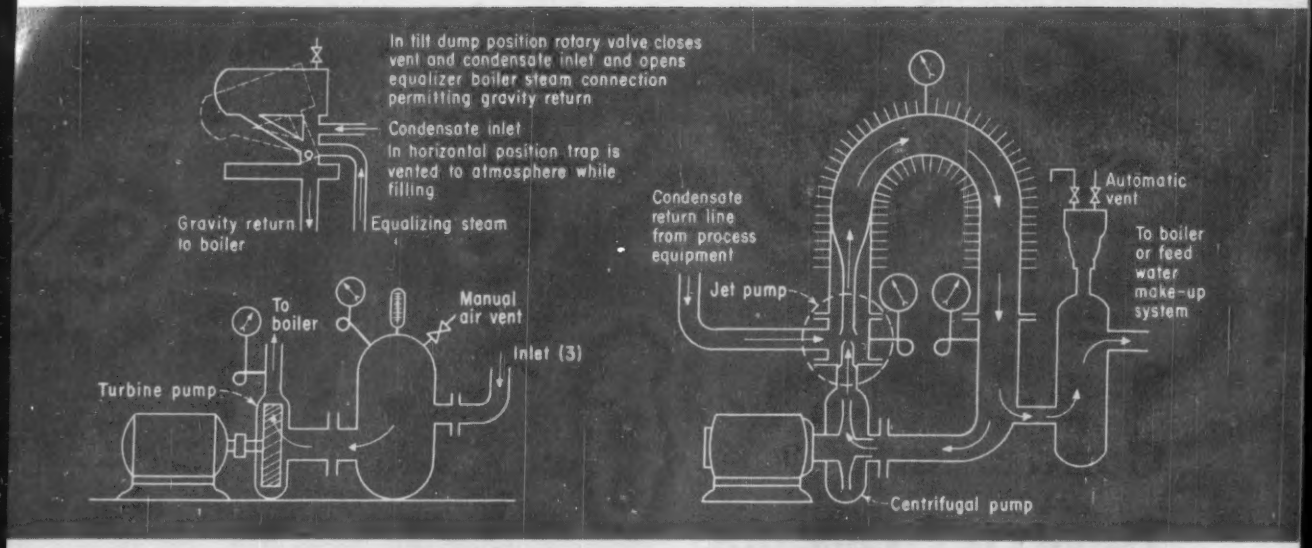
► **Traps Are Not Enough**—But the conventional nonreturn trap has limitations in many steam processing systems. Such a trap operates intermittently as condensate accumulates in the trap body before being discharged through the orifice. Since back pressure against the condensing medium alternately builds up and drops off, the average temperature and pressure head cannot be maintained at the maximum.

Also, since the nonreturn trap discharges to radically lower pressures, its orifice must be sized for two or three times the calculated maximum flow rate, to allow for flash steam that would otherwise choke the liquid flow. While this prevents static back pressure, allows free drainage of the equipment and enables boiler feed pumps to operate without steam binding, it also results in substantial water and heat losses. Aside from the cost of replacing makeup feedwater, fuel costs increase at least 1% for each 11 F. drop in feedwater temperature. Thus, condensate systems that conserve both heat and water are preferable to those that, at best, return cold water to the boilers.

Various means for recovering Btu.'s from discharged condensate have been devised, and most modern plants using steam in reasonable quantity have installed recovery systems of some type. Such systems generally fall into three classes—open, semiclosed, and closed or direct return. Drainage may be either intermittent or continuous.

► **Open Return Systems**—The most primitive of the open condensate return systems is the familiar hot-well into which condensate lines drain from several pieces of equipment. Generally, the condensate is pumped from the hot-well to a condensate storage tank where makeup feed water is added before the condensate is returned to the boiler.

Heat and evaporation losses from such systems are high. The condensate enters the hot-well at atmospheric pressure and is cooled further in the storage tank. Cooling takes place both through evaporation, which wastes water, and through mixing with cold makeup water.



Semiclosed condensate return system (above) is essentially a trap that returns condensate to boiler by gravity feed. Totally closed system (left) receives condensate at elevated temperature and pressure, pumps it to boiler. Jet pump system (right) is an improved totally closed system that overcomes some of the problems of simpler systems.

Another installation of this type is a simple heat exchanger in which condensate at higher-than-atmospheric pressure is cooled by makeup water before emptying into an open receiver. Some of the heat in the condensate transfers to the makeup water, thereby conserving heat to a small extent.

The drawing on p. 123 shows a more complex open system in which both makeup and condensate are mixed in a chamber and sprayed into the top of the receiver through a perforated distributor. Flash steam is condensed by coils carrying the cold makeup. While this system improves heat recovery, the requirements for cold makeup may cause live steam to be introduced automatically at the mixing chamber under certain operating conditions.

► **Semiclosed Systems**—Most common semiclosed systems are boiler return traps in which condensate flows by gravity to a trap above the boiler or to a common receiver at a point below the processing equipment. Venting the trap to atmosphere maintains a pressure differential that causes the condensate to flow into the trap body. When the trap is filled, tilting of the trap body or action of a float arm operates a rotary valve. Condensate inlet and vent openings close and boiler steam is admitted to the trap through an equalizing line. The condensate then drains by gravity to the boiler. We show a schematic of such a device in the drawing above.

Heat losses occur through flashing while the trap is filling, but considerable savings over open systems are realized. However, intermittent operation may cause processing difficulties and drainage capacities are relatively inflexible.

► **Closed Systems**—Simplest of the closed system designs consists of a small manifold, into which condensate flows by gravity, and a pump—usually of the turbine type—which returns the condensate directly to the boiler. Applications of this system are limited, however, by problems of steam erosion of the pump and the necessity for venting noncondensible gases. The unit also requires a high static inlet head to prevent flashing.

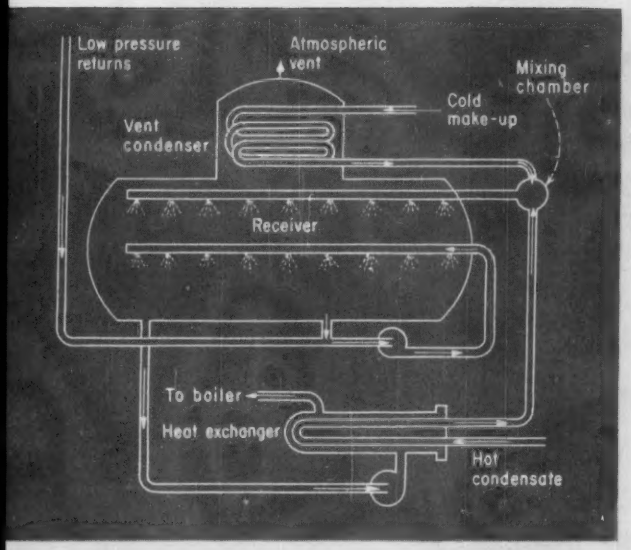
A more recent development in closed condensate return systems consists of a device that combines a centrifugal and a jet pump in series in a closed circuit, with the centrifugal pump energizing the jet pump. We also show this unit in the illustration on this page.

The centrifugal pump operates continuously, drawing water from a priming loop and discharging a high velocity jet through the nozzle. This jet strikes the returned hot condensate and induces flow through the venturi-shaped mixing tube into the priming loop.

Compare performance of condensate systems

	Jet Pump	Trap Device	Restricted ⅜-in. Orifice	Unrestricted ¾-in. Orifice
Time, min[1]	5.1	6.9	7.7	8.6
Steam required, lb.	78	85	90	105

1. Time and steam required to heat 417 lb. water from 43 F. to 212 F. in a jacketed kettle.



Open condensate return system operates at atmospheric pressure, mixes makeup water with condensate. Though better than a hot-well, system wastes both heat and water.

Any addition of condensate to the already filled loop results in the discharge of an equal volume through the air separator to the boiler.

This unit automatically maintains a back pressure equivalent to the saturation temperature of the condensate, and can draw no more steam than is necessary to raise the circulating water in the loop to saturation temperature. Proper design can hold the steam rate to that necessary to maintain the turbulent flow needed for effective heat transfer in the process equipment.

It is not necessary to have a separate jet pump for each unit of condensing equipment because all units operating at the same initial pressure can be connected to a common return line. Where variable equipment pressures require flow regulation devices, the closed system can be added to existing trap installations. Inverted-bucket traps work particularly well in this application. Because of high back pressure, there is only a slight pressure drop across the trap orifice, and intermittent trap action changes to modulated flow in direct relation to the condensing rate.

Jet return systems can establish discharge heads up to 200 psig. higher than the steam pressure in the process equipment.

► **Closed Systems Save Money**—Savings in fuel and water, increased production and improved product quality, or a combination of these factors, can justify the increased cost of a closed condensate system over that of an open system.

In many large chemical process plants, for example, it is considered uneconomical to return condensate to the boiler because of the cost of piping. But in a number of such cases, the combined savings in heat and feed water made possible by a closed condensate return system have fully justified the cost of return piping.

Increased production resulting from the better latent-heat transfer possible with jet return systems can frequently justify installation costs. Illustration: to increase production, a large chemical company made a number of modifications to a continuous feed dryer that was processing titanium dioxide. The engineers added drying coils until they believed the production limit of the dryer had been reached.

But management soon found that steam costs had risen to uncomfortably high levels—the dryer was using about 10,000 lb./hr. of 130-psi. steam to produce 50 tons/day of titanium dioxide.

The existing condensate removal system was a conventional open type, with individual traps installed on each coil discharging to a condensate header that emptied to a hot-well near the dryer.

After evaluating probable savings, the company installed a jet-pump closed system in the boiler room where it could discharge directly to the boiler or the deaerating heater, if desired. The condensate header at the dryer was connected through a surge tank to an overhead return line nearly 900 ft. long.

With the closed system in operation, steam consumption dropped from 10,000 lb./hr. to 6,000 lb./hr. Even more significant was a rise in production from 50 to 65 tons/day, resulting from higher back pressure on the dryer and adequate continuous drainage.

The table on the opposite page gives an indication of the relative performance of different methods of condensate handling. The $\frac{3}{4}$-in. orifice in the fourth column was oversize, while the $\frac{1}{8}$-in. orifice was close to proper size for the process conditions. Inability of the larger orifice to maintain adequate temperature and pressure head in the condensing medium caused the difference in process time. As you would expect, the trap device gave better heat transfer than the orifice, and the closed system improved efficiency still further.

Whether or not a closed system is applicable to a particular process must be determined by an analysis of operating conditions. But it is clear that the possible economies of more efficient condensate handling warrant careful study.

Meet the Author

RALPH J. LUNDRIGAN has been manager of Cochrane Corporation's CB Division for nearly twenty years. Prior to joining Cochrane, he spent two years in research and development work on condensate drainage problems.

Mr. Lundrigan's long interest in condensate drainage began shortly after World War I when he was Production Manager for a food processing plant. Later, he was Vice President in charge of production for eleven plants of United Fruit Products, Inc.

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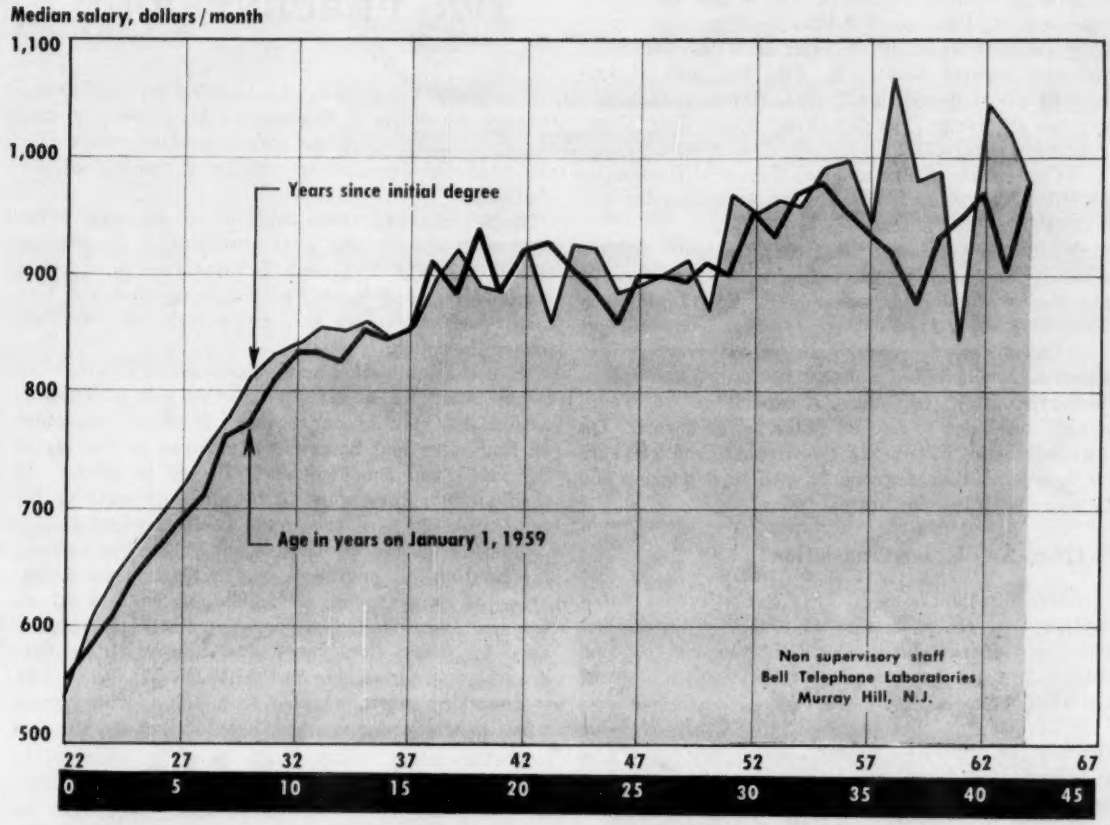


What Basis for Comparing Salaries?

A suggestion has been made that a satisfactory way to correlate existing salary data is to plot median dollars vs. calendar age as a standard abscissa.

RAYMOND F. FREMED
Associate Editor

If you collect scraps of salary information, as we do, you are familiar with the distressing lack of uniformity in the way the data are reported.

It would be both convenient and valuable to be able to compare results—on some sort of standard basis—of salary surveys sponsored by the many different organizations that engage in this activity. (Perhaps it's time for an American standard covering an approved method for issuing salary information.)

Most plots of the data put dollars on the ordinate. On this side of the graph, the major difference in opinion is whether the median or the average should be used. As engineers become more sophisticated statistically, the superiority of the median over the average requires less and less explanation.

Another suggested ordinate is a ratio of present salary to the current starting rate. This method sheds some light on the problem of compensation for older engineers and deserves further study. However, it is still a dollar value—a dimensionless ratio, this time —that is plotted on the ordinate.

It's the abscissa that causes most of the trouble. Here are some of the popular variations:

- Engineers Joint Council reports annual salary vs. year of entry into the profession (the year in which the engineering baccalaureate was awarded). For details of the 1958 EJC salary survey see *Chem. Eng.*, Mar. 23, 1959, pp. 188-192.
- Bureau of Labor Statistics is now surveying en-

gineering salaries on the basis of the going rates for six carefully defined job levels. For details see *Chem. Eng.*, Jan. 11, 1960, pp. 120-122.

• National Register of Scientific and Technical Personnel reports salaries vs. field and type of employer, highest degree held, work activities and ten-year age groupings. For details see *Chem. Eng.*, June 13, 1960, pp. 221-222.

• Conference of Professional Technical Personnel, Inc. (Bell Telephone Laboratories), uses calendar age as their preferred abscissa.

• Engineers & Scientists of America issues a chart of salary vs. "quality" percentile, with year of entry into the profession as parameter. For details see *Chem. Eng.*, July 11, 1960, pp. 140-144.

• Other surveys correlate salary with years of experience. A widely used conversion factor from "years since graduation" or "years of experience" to "years of age" has been to add 22 years to the former. On the other hand, EJC in its 1958 report used 21 years for those with B. S. degrees, 22 with M. S. degrees and 24 years with the doctorate.

Is There Any Exact Translation?

In the July 1960 issue of *C.P.T.P. Conference Notes*, published by an association of professional technical employees of Bell Telephone Laboratories, the suggestion is made that calendar age be used as a standard abscissa for all salary surveys.

In support of this proposal, the Conference has checked the replies on its 1959 salary survey of non-supervisory staff at BTL and plotted monthly salary vs. years since initial degree as well as age in years on Jan. 1, 1959. As you can tell from our reproduction of this chart on the previous page, the 1959 Conference salary survey shows an excellent correlation between these two measures of age.

Monthly salaries for 1,475 nonsupervisory respondents are represented on the chart by median values. Replies from those employees who had no academic degree were removed for this comparison.

When a separate plot is made to show a difference in salary vs. calendar age (difference = median salary for years since initial degree minus median salary for age in years), the average difference was \$17/month. That is, the "years since initial degree" curve was an average of \$17 higher than the "age in years" curve when the two are assumed to differ by 22 years.

The standard error of this difference was computed at \$15; however, the differences were not normally distributed. If the 22 years displacement were made 23 years, the average error would be reduced to \$8/month. A 24-year difference would invert the curves by \$4/month. Moving the difference in years between the two measures from 21 to 25 years did not change the standard error significantly.

Therefore, CPTP is convinced that its correlation of salary vs. calendar age is quite satisfactory and recommends that it be considered as a basis for comparing salaries of diverse groups.

PROFESSION PROFILE IS TWO PERCENT DONE

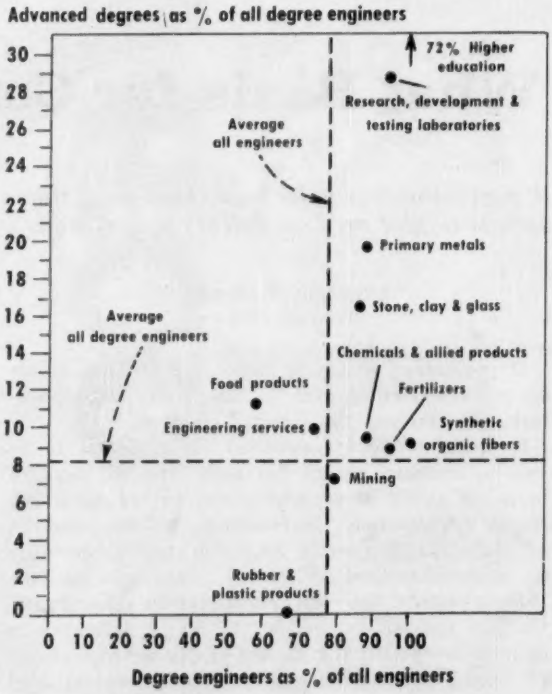
For many years now, the engineering profession, through the efforts of Engineering Manpower Commission and Engineers Joint Council, has been publicizing the need for someone to conduct a "profile of the profession."

Some years ago, there was talk of spending \$100,000 on such a project. This year, EJC is considering the advisability of accepting several million dollars from National Science Foundation to find out how many engineers there are, where they are and what makes them tick.

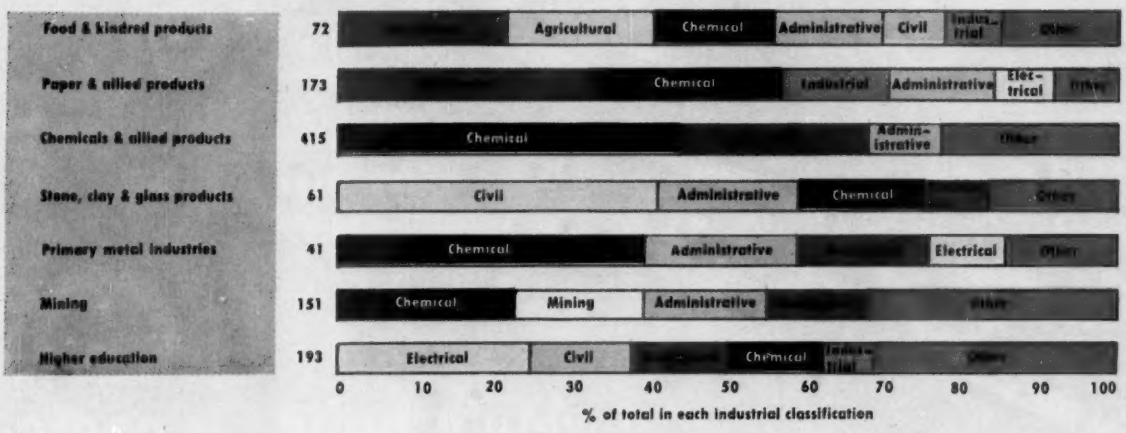
A recent publication by the Science and Engineering Center Study at the Univ. of Florida now provides us with a 2% view of our profile. It is an "Inventory of Engineers and Scientists Employed in Florida in Jan. 1958 and Employment Projected to 197X." If such an inventory were to be made by each of the remaining 49 states, the profile would be complete.

The Florida report, dated April 1960, gives valuable information on engineers and scientists including: areas of employment, specialization, educational attainment, employment by educational attainment, prospects for future employment, etc. Supplementary data are given on physicians and dentists.

The chart below, adapted from the Florida report, gives a general summary of employment by industry



Job opportunities for chemical engineers in Florida



and educational attainment. The vertical scale shows the percent of all degree engineers who have advanced degrees and the horizontal scale measures degree engineers as a percentage of all engineers employed. Dotted lines are the over-all average values.

Of the 8,425 engineers working in Florida in 1958, 70% had first degrees, 23% had no degree, 6% master's degree and only 1% held the doctorate. Private enterprise employed 80% of the engineers, 18% worked for municipal, county, state or federal government and 2% of the engineers were employed by educational institutions.

The table on this page shows the distribution of engineers in various fields of employment, according to engineering discipline. We've selected only those industries that have substantial requirements for chemical engineers. Of course, chemical and allied products lead the list, but note the unusually large percentage of chemical engineers in the mining operation in Florida.

Estimating their future demands for engineers, the employers of 8,105 engineers in 1958 estimated that they would need 11,103 engineers in 1960. In the years immediately ahead, perhaps for the next decade, Florida expects to add 9% to its engineering force each year. It's possible that there will be jobs for 31,400 engineers in 1970 and 74,400 by 1980 if the current 9% annual rate of growth is maintained.

However, the report explains that it is improbable that this growth rate can be sustained for the next 20 years.

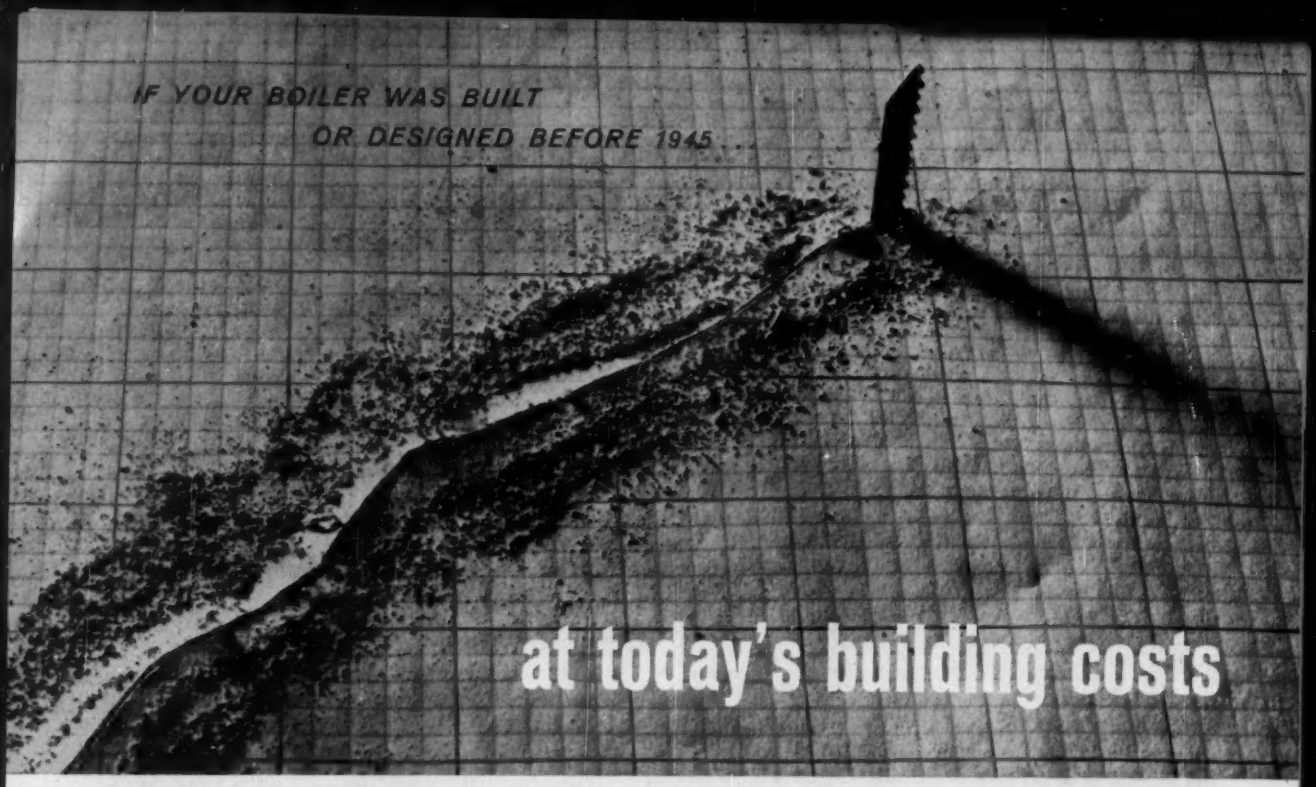
One of the report pages that caught our eye was a tabulation of the number of technicians employed in support of engineers in various fields. While governmental agencies, utilities, metalworking industries are using as many as 231.5, 178.6, 119.0 technicians per 100 engineers, the chemical and allied products industries use only 16.4 technicians to support the work of each 100 engineers.

Where to look in Fairfield County

Commendation is due the young and vigorous Fairfield County (Conn.) Section of the American Institute of Chemical Engineers for compiling a directory of companies related to chemical engineering in their territory. Purpose of the manual is to help acquaint chemical engineers with organizations that might be of interest to them in their professional careers, or for general information.

Nearly 200 companies are listed with addresses, a code indicating number of employees, products manufactured, services offered or fields of interest. The directory was compiled by Leon M. Hecht, Jr., of Pitney-Bowes Co., Stamford, Conn.

First copy was presented to Mayor Kennedy of Stamford, which was recently renamed "The Research City." Shown in the photo above are, in the usual order, Hecht, Mayor Kennedy and Arthur J. Weinberger, first chairman of the Fairfield County Section. Copies of the directory are being sent to all school science supervisors, newspapers and chambers of commerce in the area.



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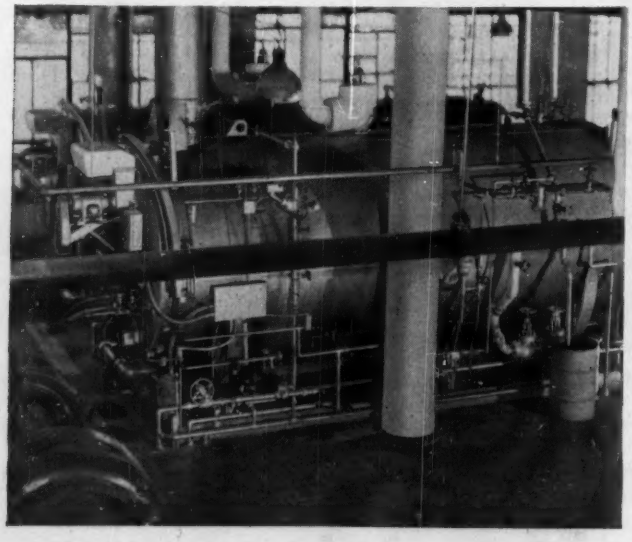

Today, with building costs twice what they were in 1945, your big, old boiler — possibly coal-fired — can cost you money by occupying space that might be used for other needs.

To offset these climbing construction costs and meet the compact requirements of modern architecture, one manufacturer, Cleaver-Brooks, has proved that big boiler performance and capacity can be engineered into a compact boiler package. Today's CB packaged boilers — in addition to solving unusual installation problems, such as low headroom — are releasing sizeable ground-level areas for production or storage purposes. In some cases, "penthouse" installations have utilized space on an upper floor and *completely eliminated* the use of ground-level space.

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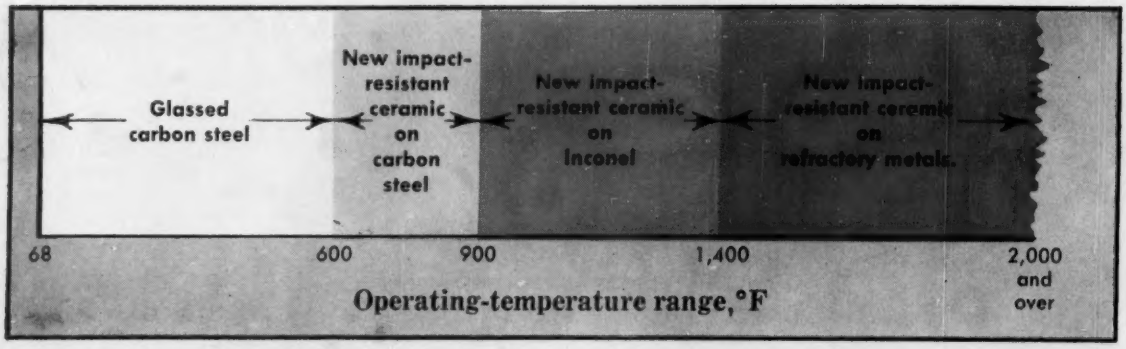


New Ceramic-Coated Metal Takes Over Where Glassed Steel Leaves Off

A new family of ceramic-coated metals, with excellent impact strength and resistance to hot chemicals, promises to solve many high-temperature problems.

As the drawing above shows, a new family of ceramic-coated metals, just introduced by The Pfaudler Co., can handle much higher temperatures than glassed steel.

▶ **Impact Resistant**—But the considerable amount of interest stirred up by the novel ceramic-metal combinations (called Nucerite) is based on more than just high-temperature resistance.

Pfaudler has come up with a cream-colored, opaque ceramic (actually crystallized glass) with an impact strength of 10.8 ft.-lb. or 18 times that needed to shatter safety plate glass.

The ceramic is not immune to mechanical damage. But Nucerite appears to confine any fracture to the point of impact (easily repaired with a tantalum plug). Pfaudler engineers have proved this point dramatically by firing rifle bullets at ceramic-metal test panels. A bullet simply crushes a section having the bullet's diameter and does not expose any bare metal.

Also, it can take a temperature difference of 1,200 F., or 3 to 4 times that of existing glassed steels and a big improvement over many other ceramics.

Abrasion resistance is 4 times better than hard glass and heat transfer is 13 times better than porcelain—new ceramic has a thermal conductivity of about 170 Btu./(hr.) (sq. ft.) (°F.) (in.).

High-temperature stability seems to be outstanding: the new ceramic has protected molybdenum from oxidation at 1,600 F. Corrosion resistance also is excellent against chemical vapors at high temperatures (above 1,300 F.)

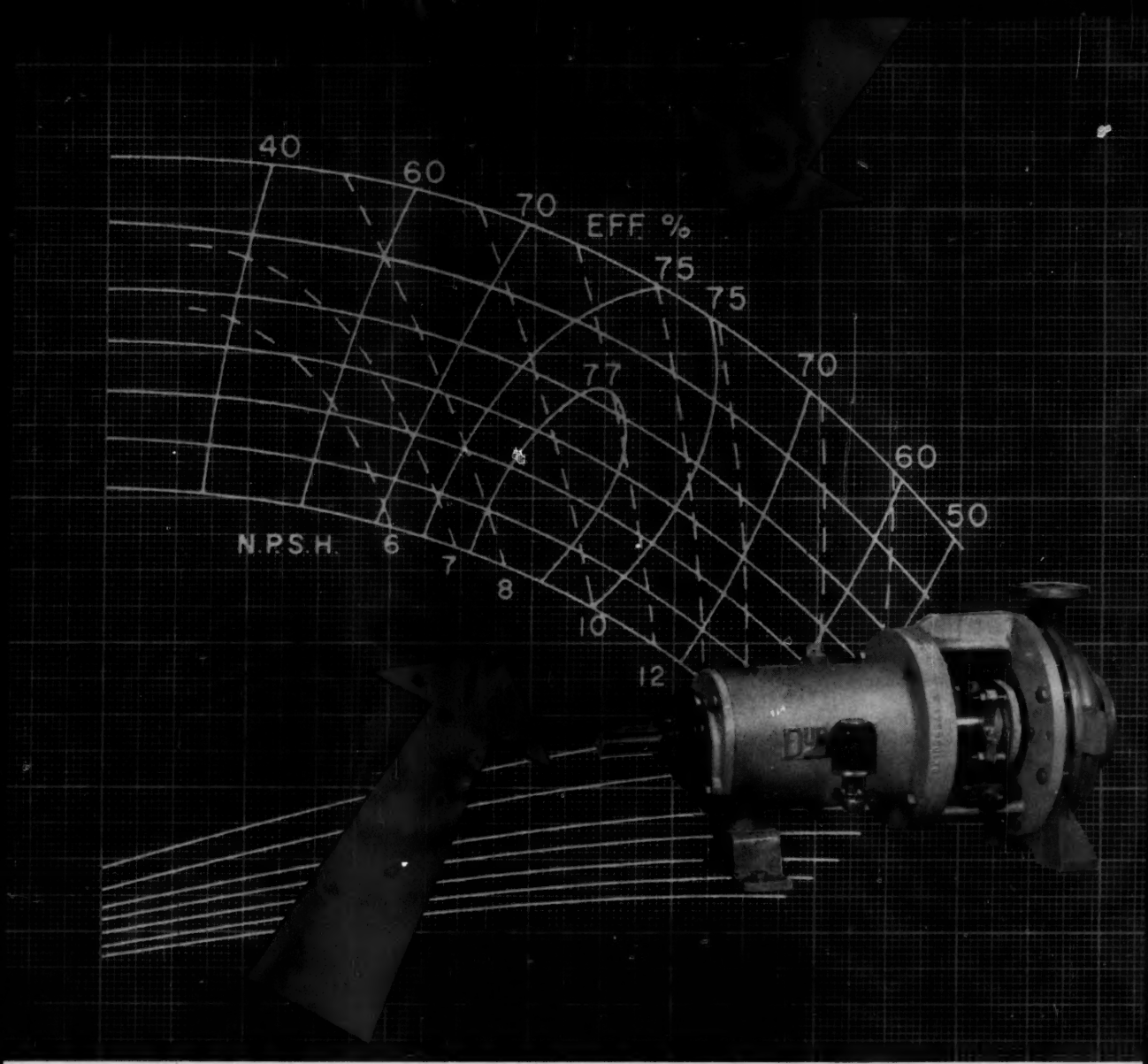
It's essentially nonporous, showing no increase in weight after long exposures to water or high humidities.

The coating can be applied to most metals, including steel, Inconel, Hastelloy, columbium and molybdenum.

▶ **Three Applications**—All these properties point to three distinct areas for process applications.

- High-temperature, vapor-corrosion situations. One chemical company is now testing some 1- and 3-in. O.D. tubing coated on the inside with 40-mil ceramic. The tubing is standing up to high-velocity, highly corrosive, high-temperature (1,300 F.) metal halide vapors in a field application where metal-alloy life is measured in days.
- Conditions where abrasion-corrosion resistance is needed at high temperatures.
- Situations at relatively low temperatures (below 600 F.) where glass would be too fragile. Actually, in aqueous environments the ceramic has the chemical resistance of a good grade of glass. This, combined with its mechanical properties, might give it an edge over metals in acid solutions.

▶ **More Work Needed**—Far from a finished product, the ceramic coating is still in the development stage.



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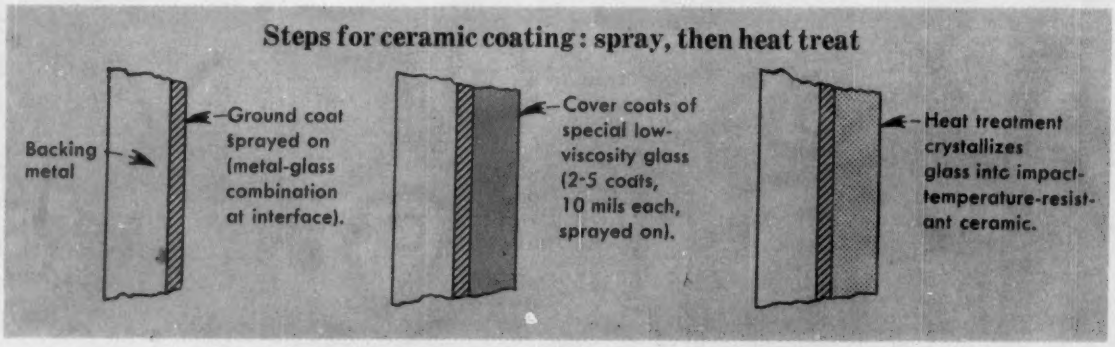


Pfaudler has successfully coated small reaction vessels and tubing but it will take substantial additional work to transform Nucerite to full-scale production.

An extended period of selected field testing is planned before any production facilities for handling large equipment are established.

Much of the ceramic coating will be done on a custom basis.* Costs are difficult to come by, since Pfaudler has relatively little experience, to date, on actual commercial jobs. The most that can be said now is that the ceramic coating will be more expensive than a glass coating, but just how much more expensive will depend a great deal on complexity and size of the part. At any rate, the ceramic will not displace glassed-steel, except where the added cost can be justified.

On high-temperature problems over 1,600 F., where refractory metals have to be used, the ceramic coating will be a relatively minor cost item, compared to the base metal.

▶ **What Is It?**—Actually, the ceramic is not far removed from glass—it is crystallized glass in the same family as Corning's Pyroceram. However, Pfaudler believes Nucerite is unique—the result of "closely controlled nucleation and crystallization within certain ceramic formulations."

Patents are pending* and Pfaudler is reluctant to give out specific processing details. But generally the technique involves applying a ground coat of glass on bare metal, forming a metal-glass combination at the interface. Then from two to five coats, 10 mils each, of special, low-viscosity glass are separately applied and fired and the "package" heated to about 2,000 F. Agents, added to the glass, act as nucleation centers during the heat treatment. Result is a hard, dense structure with a large number of very small crystals (an electron microscope must be used to see them).

Pinholes are no problem; the technique produces a "high-integrity" coating.

Coating pipe or tubing is relatively simple: one end of the pipe is closed up, a glass emulsion poured in the open end and the excess poured out. The usual firing and application of successive coats follows.

▶ **Some Limitations** — There are some limitations, however, to this new material. A thick coating can't be built up on sharp corners. And Pfaudler does not recommend it for thin metal sections. However, design can compensate for these situations.

Finally, the ceramic appears to have a slightly rougher surface than glass. This particular characteristic is being evaluated. Some ceramic-coated steel panels are under test in a polymerization plant.

* Different backing metals call for somewhat different ceramic formulations.

* Climaxing five years of research at Pfaudler laboratories and at an eastern university.

How ceramic-coated metal compares

Tensile Strength: Ceramic component withstands more tensile stress than mild steel.

Impact Strength: Withstands 10.8 ft.-lb. of point impact strength, or about 18 times that needed to shatter safety glass.

Thermal Shock: About 300 to 400% increase in resistance to thermal shock over existing glassed metals (ΔT of 1,200 F.)

Abrasion: Some 400% more resistant to abrasion than laboratory glass. Hardness ranges from Rockwell C23 to C50.

Heat Transfer: Ceramic thermal-conductivity is 13 times higher than porcelain or 170 Btu./(hr.) (sq. ft.) (°F.) (in.)

High-Temperature Stability: Protects molybdenum from oxygen at 1,600 F. Ceramic can be formulated to withstand temperatures over 2,000 F.

Many polymers, especially synthetic rubbers, vinyl and styrene plastics will not adhere to a smooth glass surface, but will stick to metal, even highly polished metal. For this reason polymer processing equipment represents a big market for glassed steel—any polymer buildup on piping or vessel walls will drastically reduce heat transfer. If the new ceramic-steel also prevents polymer adhesion it will probably take a good slice of this market, particularly where mechanical damage or thermal shock are problems.

► **Not Same Class**—Pfaudler engineers stress the point that this new material is not in the same class as other glass-type coatings, particularly porcelain enamels. These enamels don't have the chemical resistance of glass, and while some porcelain coatings can stand up to temperatures of 1,000 F., their thermal shock resistance is poor—temperature differences of 350 F. is about the limit.

There are some refractory coatings used on metals to increase temperature resistance. They are mainly applied by spray or dip techniques but process applications have been limited to thermowelds, pipe reactors and furnace parts because of porosity, high costs and poor impact strength.

Also, flame-spray coatings of refractory materials do not seem to offer the Pfaudler ceramic much competition at present for corrosive applications. Flame-sprayed ceramic coatings are somewhat porous and brittle.

Quick Way to Check Mill Scale Removal

One of the most important steps in preparing steel surfaces for a coat of paint is removal of mill scale. To be really effective the paint or protective coating must be applied to a clean metal surface. There are numerous techniques available for getting the mill scale off, ranging from wire brushes to shot or sand blasting. But how can you be sure all the scale has been removed? A surface that appears clean to the eye could be covered with residual scale which will reduce the effectiveness of any protective coating.

Engineers at the research center of Shell Research, Ltd., Thornton, England, have developed a quick, simple and inexpensive method of checking mill scale removal.

The technique calls for applying a solution of copper sulfate to freshly cleaned steel surfaces. Areas entirely free of scale will become coated with copper, while any scale shows up as a dark area against the copper background. All that's needed is an impregnated pad or sponge and visual inspection.

Metavanadate: Effective Corrosion Inhibitor

Sodium metavanadate, according to the Vanadium Corp of America, has proved to be an effective and economical corrosion inhibitor in alkaline amine-gas scrubbing systems. Small concentrations of soluble vanadates are capable of forming a protective coating that greatly lessens corrosive attack on carbon-steel process piping.

Recommended inhibitor concentration is 0.05 weight %. Actually, any residual vanadate in the monoethanolamine (MEA) solution beyond that required to coat the process piping is adequate to minimize corrosion.

Initial consumption of vanadate is probably the result of a deposit or coating on the piping. However, once the original coating is formed, further vanadate consumption is small. The addition at startup of from 2 to 2½ times the calculated amount of sodium metavanadate insures formation of the coating and provides for the recommended residual concentration. No decomposition of the vanadate in service for over 1 yr. was noted in tests. Excess vanadate will not damage the system.

Sodium metavanadate dissolves readily in hot water and can be added in this way to the gas-scrubbing system. But normal precautions to avoid inhaling excessive sodium metavanadate dust must be observed at all times (nose and mouth mask).

In systems where hydrogen sulfide is present, vanadium sulfide may precipitate, but this does not impede the corrosion inhibition of sodium metavanadate or the efficiency of the amine solution. However, the amine solution should be circulated after addition of the sodium metavanadate and before contact with the hydrogen sulfide.

Concentration of vanadium in the amine solution should be determined periodically in a laboratory setup, and small additions made to the plant streams, as required. Vanadium Corp. of America has developed a simple laboratory method for determining vanadium in MEA solutions.

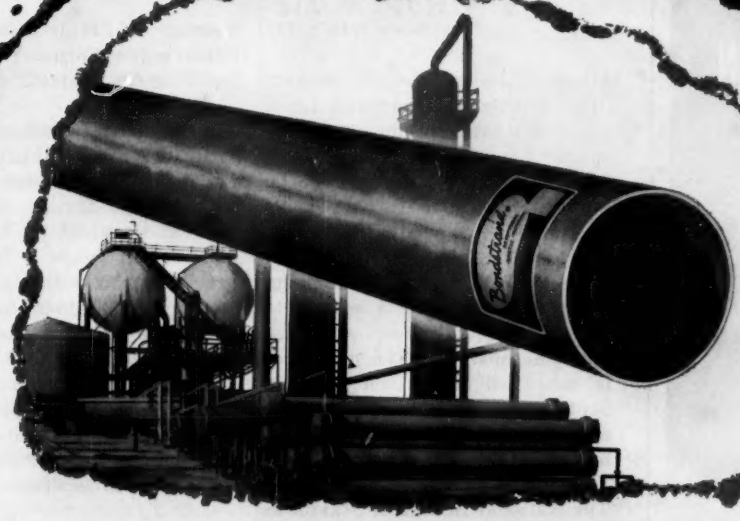
New Standard for Polyethylene Pipe

Improvements in flexible polyethylene plastic pipe are reflected in a recommended revision of Commercial Standard CS-197-59 which covers this product.

Recently submitted to industry for consideration and acceptance, it was prepared (in cooperation with the Society of the Plastics Industry) by the Commodity Standards Div. of the U. S. Dept. of Commerce.

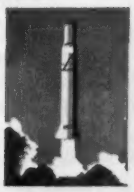
The revision covers requirements for material, workmanship, dimensions, working pressure, field pressure, incremental pressure, sustained pressure and environmental cracking for three types of resin, one schedule and two series of polyethylene pipe, used principally for conveying potable water. Methods of marking and indicating compliance with this standard are included.

Copies of the recommended revision, designated TS-5496, are available from H. A. Bonnet, Commodity Standards Div., U. S. Dept of Commerce, Washington 25, D. C.



BONDSTRAND®

An imaginative solution to your piping problems



From Missile Research...

A new product for process piping

- Twice as strong as steel
- 1/4 the weight of steel
- Inherently resistant to chemicals which attack stainless steel

Bondstrand is a corrosion-resistant, high strength, rigid pipe made of glass filaments bonded in chemically inert synthetic resins. It is capable of withstanding high pressure and the corrosive attack of many salt, acid, and alkaline solutions. The outside surface is equally resistant because the pipe is made entirely of corrosion-proof materials. No painting or maintenance is necessary.

Bondstrand's light weight and ease of assembly can save up to 50% of installation costs. Actual cost records of typical applications prove that the total installed cost averaged only 1.3 times that of carbon steel pipe. By eliminating the corrosion problem and down time for replacement or repair, Bondstrand saves many times its slightly higher initial cost.

Bondstrand is now available in sizes from 2" through 8" with all necessary couplings and fittings. Larger sizes available on special order.

Write for bulletin containing complete data, including physical properties, chemical resistance, flow rates, and other design information.

Amercoat® CORPORATION

129

A Subsidiary of American Pipe and Construction Co.

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921 Pitner Ave., Evanston, Ill. • 360 Carnegie Ave., Kenilworth, N.J. • 111 Colgate, Buffalo, N.Y. • 2404 Dennis St., Jacksonville, Fla. • 6530 Supply Row, Houston, Tex.

(continued from p. 52)

Allied Chemical Corp.'s Barrett Div. recently broke ground for a plant that will produce gypsum board by chemical processing. Feedstock to the facility will be byproduct gypsum from wet-process phosphoric acid manufacture conducted nearby by Allied's General Chemical Div.—Allied chemists have developed a means to remove residual phosphoric acid from this material. The new plant is scheduled to be completed in September, 1961; it will be able to make enough gypsum products to build 32,000 homes a year.

The National Bureau of Standards will start construction during the next ten months on the first buildings to be erected at its new laboratory site at Gaithersburg, Md. The Bureau acquired a tract of about 550 acres there four years ago, will eventually build 20 buildings to house new research facilities as well as all of its present projects. Total cost of the program will be about $104 million. By moving from Washington, D. C., to the new site, the Bureau will remove its work from the influence of mechanical, electrical and atmospheric disturbances that exist in a city. First facilities to be erected will be an engineering mechanics laboratory and a power plant, expected to be completed in late 1962, and a radiation physics laboratory scheduled for completion in the spring of 1963.

Shell Oil Co. has awarded a contract for expansion of liquid recovery facilities at its Provident City, Tex., gas plant. New additions, consisting mainly of a refrigeration system to treat incoming gas, will permit the plant to increase propane production from 21,000 to 33,000 gal./day, and to up natural gasoline output by about 5,000 gal./day. Project will have no effect on the total gas intake for the plant, which is currently 75-80 million cu. ft./day. Construction is to start this month, to be completed during the first quarter of 1961. Gasoline Plant Construction Corp., of Houston, is handling the project.

U.S. Industrial Chemicals Co., division of National Distillers & Chemicals Corp., has increased ammonia production capacity by 17% at its plant at Tuscola, Ill. New output figure is 70,000 tons/yr. The firm will also install a tank of 6,000 tons capacity for storage of anhydrous ammonia; it is expected to be in full service by the end of the year. Tank will store liquid ammonia at about −28 F. and atmospheric pressure, rather than at higher pressure and moderate temperature.

Allied Chemical Corp.'s National Aniline Div. is expanding its caprolactam facilities in Virginia. Capacity for making the monomer at Hopewell is being increased by 75%, and the company is also expanding manufacturing units for caprolactam polymer, Golden caprolan nylon tire yarn and other products at its plant in Chesterfield. Completion of the multimillion-dollar program is scheduled for mid-1961.

Rexall Chemical Co. and **El Paso Natural Gas Products Co.,** which have announced a joint venture into petrochemicals manufacture (*Chem. Eng.*, June 27, 1960, p. 152), reveal plans to build research laboratory and office facilities at Paramus, N. J.

Ashland Oil & Refining Co. has a new 32,000-bbl./day vacuum distillation unit under construction at its No. 2 Refinery in Catlettsburg, Ky. Scheduled for completion next spring, it will replace three smaller vacuum units, will become a part of the refinery's existing 75,000-bbl./day crude facility. Badger Mfg. Co., of Cambridge, Mass., is handling the project.

Hooker Chemical Corp. is embarking on production and sale of perchlorethylene in the West. Company's Western Chemical Div. is

manufacturing the chlorinated solvent in a new production unit at its plant in Tacoma, Wash.

Monsanto Chemical Co. has increased its production capacity for maleic anhydride at St. Louis. New capacity amounts to 60 million lb./yr.

Pennsylvania State University has acquired for its research and education programs the Curtiss-Wright nuclear center at Quehanna, Pa. The multimillion-dollar center includes a 4-megawatt swimming-pool reactor, hot cells capable of containing 10 million Curies of radiation, and radiochemistry laboratories. Curtiss-Wright donated the facilities to the university after a realignment of the corporation's research program.

Nopco Chemical Co. is building a $550,000 plant to make foam polyurethanes at Chattanooga, Tenn. Facility will consist of a one-story building, which is slated to be in operation by March 1961. Engineers, Inc., of Newark, N.J., is designing the plant.

Celgar Ltd., Canadian affiliate of Celanese Corp. of America, nears completion of a 500-ton/day bleached kraft pulp mill at Castlegar, B. C. Mill is due to start production by the end of this year, and its completion will culminate a 2½-year construction program. It occupies a 545-acre site on the Columbia River, lies 18 miles north of the U. S. border.

Webb & Knapp Co., Inc., plans to build a steel mill at Anaconda, Mont. Facility will produce about 350,000 tons/yr. of steel from slag, will also conduct reclamation operations for copper and zinc. It is due to start up in 1962.

S. B. Penick & Co. has completed a 2½-year expansion and refinement program for its facilities at Newark, N. J., where the firm carries out fermentation and purification operations in making antibiotics. Total cost was $1.25

million. Penick uses the facilities to produce its own antibiotics, and also makes them available to its pharmaceutical - manufacturing customers for fermentation work.

Chemical Lime, Inc., is a new company formed in Florida to produce quicklime and hydrated lime for the chemical processing and other industries in the state. Firm is building a $2-million plant at Brooksville, Fla., which is to go on stream next summer with a design capacity of 200 tons/day. Plant is being engineered and constructed by Dorr-Oliver Engineering, Ltd., of Stamford, Conn.

Minnesota Mining & Manufacturing Co., of St. Paul, Minn., and **Warner - Lambert Pharmaceutical Co.,** of Morris Plains, N. J., are discussing a merger of the two companies. Each firm conducts a diversified line of activities, with no areas of competition between products. Merger will require approval by directors and stockholders of both companies.

American Foundation for Management Research, Inc., is the name of a new philanthropic organization that has been established to carry out and sponsor research in the field of management. All foundation members are personnel from the executive committee of the American Management Association. The AMA has granted the foundation $55,000, will give it an additional $90,000 during the next 11 months.

UBS Chemical Corp., of Cambridge, Mass., and **The Permutit Co., Ltd.,** of London, have announced a joint venture for manufacture and distribution of the Cambridge firm's UBATOL polymer emulsions. Products will be made at Permutit's chemical works in Ponty Clun, Glamorgan, in South Wales, and distributed throughout the United Kingdom and Europe.

OVERSEAS BRIEFS

England: Esso Petroleum Co. Ltd. will build a $12-million butyl rubber plant at its refinery at Fawley, Southampton. Capacity will be about 30,000 long tons/yr. No firm date has been announced for start of construction, which will require two to three years. The plant is expected to meet all of the United Kingdom's requirements for butyl rubber, currently imported from the U. S. and Canada.

India is studying a project report on a fourth state-owned steel plant, for which an allocation of $420 million has been made in the country's third Five-Year Plan. The report, prepared by an Indian consulting firm, suggests that the plant make steel by the L-D basic oxygen process and that it initially produce sheets and plates only. Initial output is to be 1 to 2 million tons/yr., but eventual capacity has been set at 4 to 6 million tons/yr. Plant is to be at Bokaro in the West Bengal State.

France: Societe Anonyme Reichhold Beckacite, France, an affiliate of Reichhold Chemicals, Inc., of White Plains, N. Y., will build a 10.5-million-lb./yr. maleic anhydride plant at Niort, Deux-Sevres. Scientific Design Co., Inc., of New York, will design the plant, will grant a license for the use of its maleic anhydride process.

India's government has signed a plant-construction contract with a German group representing Badische Anilin- und Sodafabrik, Farbenfabriken Bayer, Farbwerke

Hoechst and the Hoechst subsidiary, Friedrich Uhde. The plant, to be built near Bombay, will manufacture 40 semifinished products—dyes, varnishes, rubber auxiliary agents and pharmaceuticals—from toluene, benzene and naphthalene produced in Indian coking plants. The German group will supply production know-how, will plan and supervise the construction. Facility is to go on stream in 3-4 years, will cost about $26 million.

Italy: Members of the press recently visited a new $22.4-million petrochemical complex at Ragusa, Sicily, built by the ABCD Co. The plant will process 250,000 tons/yr. of crude oil from Ragusa wells; its product slate will include about 12,000 tons/yr. of polyethylene. This will constitute the first plastics facility on the island to carry out its operations exclusively with Sicilian-produced raw materials. Almost all of the plant's machinery is of German manufacture. Another polyethylene plant in Sicily, owned by the Celene Co. of Palermo and located in the province of Syracuse, is being expanded so that it can produce other similar products as well. The Export-Import Bank is financing the expansion with a loan of over $2.8 million, which will be used to acquire materials and technical assistance from the U.S. Plant's equipment comes from Union Carbide International Co., New York.

Spain: Dow Chemical Co. and Union Quimica del Norte de Espana (Unquinesa) have entered into an agreement to build a petrochemical complex in Spain. Dow will purchase a new issue of Unquinesa stock, will make technological know-how, engineering and marketing assistance available to the Spanish company, which will probably change its name to Dow-Unquinesa, S.A. Development plans call for building a cracking unit to produce ethylene and propylene, with the resulting C_4 fraction treated further to produce butadiene. These basic materials will then be used to manufacture a wide range of chemicals and plas-

tics, such as polyethylene, polypropylene and polystyrene.

Italy: Cornigliano Sp.A. will begin full-scale use of oxygen next year in the six open-hearth furnaces at its steel mill in Genoa. This move, along with installation of basic roofs, is expected to increase the furnaces' total output from about 1 million to 2 million metric tons/yr. Oxygen will be supplied by a 426-ton/day plant being built at the mill by Air Products (Great Britain) Ltd., British affiliate of Air Products, Inc., of Allentown, Pa.

Mexico: Celanese Mexicana, S.A., affiliate of Celanese Corp. of America, will expand its facilities at Ocotlan in the State of Jalisco for producing filament nylon yarn. Expansion is due to be completed late next year; it will add 1,000 tons/yr. of new capacity, approximately doubling the present level.

Japan: Miike Gosei Chemical Industry Co., Ltd., Omuta, Kyushu, will build an 8-million-lb./yr. maleic anhydride plant. Facility will use Scientific Design's process involving fixed-bed catalytic air-oxidation of benzene.

Colombia: B. F. Goodrich Chemical Co., Cleveland, plans to join with undisclosed Colombian participants in building a plant in that country for manufacture of geon vinyl plastic materials. Facility will be near an existing factory belonging to Planta Colombiana de Soda, near Bogota, which will supply the new venture with one of its primary raw materials, chlorine. Plant construction is to start soon and production is expected to begin early in 1962.

Holland: N. V. Transicol, a Netherlands subsidiary of Heyden Newport International Corp., is starting construction of a plant to produce para-methane hydroperoxide, used as a catalyst in making synthetic rubber. Facility will be at Geertruidenberg, where Transicol already conducts manufacturing operations.

Thailand's first catalytic petroleum-processing installation will be built outside Bangkok, is slated for completion late next year. A cracking unit, it will operate at high conversion levels to produce stocks for manufacturing aviation gasoline and high-quality motor fuel. The venture is based on a licensing agreement recently completed between Houdry Process Corp., of Philadelphia, and the Thai government's Defense Energy Department.

Mexico: Sun Chemical Corp., of New York, has started construction at Toluca on a plant to produce pigments. Scheduled to be on stream by December 1, it will operate under the name of Ansbacher-Siegle de Mexico, S.A., as part of Sun's International Operations Group. It is expected to be the largest facility of its kind to serve Latin America's printing ink, textile, coating and finishing industries, will offer a complete line of organic and inorganic pigments.

Japan: Dow Chemical Co.'s associate chemical firm in Japan, Asahi-Dow Ltd., has presented the Japanese government with a proposal to build a polyethylene plant at Kawasaki. Plant would use a high-pressure process developed by A. G. fur Olefin–polymerisation (AGFO process) and licensed by Scientific Design Co., Inc., of New York.

Formosa: A new company, Cyanamid Taiwan Corp., has been formed jointly by American Cyanamid Co., of New York, and Taiwan Sugar Corp. to produce pharmaceuticals and animal feed supplements. Representing an investment of over $1 million, the new firm will conduct manufacturing operations at Hsin-Chu, Taiwan, where Taiwan Sugar has been producing antibiotics for use with feed supplements. Existing plant there will be expanded, and the expanded facility is expected to be in full production in 17 months.

Convention Calendar

October

5. Society of Plastics Engineering, Inc., Plastics vs. Corrosion, Mark Hopkins Hotel, San Francisco, Calif.

6-8. American Assn. of Textile Chemists and Colorists, 1960 National Convention, Sheraton Hotel, Philadelphia, Pa.

National Assn. of Corrosion Engineering, regional conferences:
6-7. West, Sheraton-Palace Hotel, San Francisco, Calif.
6-8. Southeast, Dinkler-Plaza Hotel, Atlanta, Ga.
11-14. Northeast, Prichard Hotel, Huntington, W. Va.
14-16. Canadian (Eastern), Sheraton Mount Royal Hotel, Montreal, Que.
19-20. North Central, Pfister Hotel, Milwaukee, Wis.
25-27. South Central, Mayo Hotel, Tulsa, Okla.

6-8. American Ceramic Society, Refractories Division Meeting, Bedford Springs Hotel, Bedford, Pa.

9-12. American Society of Mechanical Engineers, Rubber and Plastics Conference, Hotel Lawrence, Erie, Pa.

9-13. Electrochemical Society, Annual meeting, Shamrock Hotel, Houston, Tex.

9-14. American Institute of Electrical Engineers, Fall General Meeting, Chicago, Ill.

11. National Petroleum Assn., Symposium on Non-Newtonian Viscometry, Mayflower Hotel, Washington, D. C.

12-14. American Vacuum Society, 7th National Symposium, Cleveland-Sheraton Hotel, Cleveland, Ohio.

12-14. Industrial Management Society, 9th Annual Methods Improvement Clinic, Conrad Hilton Hotel ,Chicago.

13-14. Industrial Management Society, 24th Annual National Industrial Engineering and Management Clinic, Conrad Hilton Hotel, Chicago, Ill.

13-14. The Society of the Plastics Industry, 16th Annual New England Section Conference, Wentworth-by-the-Sea, Portsmouth, N. H.

16-19. American Oil Chemists' Society, Annual Convention, Hotel New Yorker, New York, N. Y.

17-19. Technical Assn. of the Pulp and Paper Industry, 15th Plastics-Paper Conference, Hotel Syracuse, Syracuse, N. Y.

17-19. Institute of Radio Engineers, 1960 Symposium on Adaptive Control Systems, Garden City Hotel, Garden City, L. I., N. Y.

17-19. American Society of Mechanical Engineers & American Society of Lubrication Engineers, 7th Annual Lubrication Conference, Statler-Hilton Hotel, Boston, Mass.

17-21. American Society for Metals, 1960 Metal Show, Philadelphia Trade

and Convention Center, Philadelphia, Pa.

19-26. International Plastics Exhibition, Utrecht, The Netherlands.

20-21. Air Pollution Control Assn., West Coast Section, 2nd Technical Meeting, Santa Barbara Biltmore Hotel, Santa Barbara, Calif.

20-22. National Society of Professional Engineers, Fall Meeting, Denver, Colo.

23-27. Technical Assn. of the Pulp and Paper Industry, 156th Engineering Conference, Robert Meyer Hotel, Jacksonville, Fla.

24-26. Canadian Manufacturers of Chemical Specialties Assn., 3rd Annual Meeting and Conference, Queen Elizabeth Hotel, Montreal, Quebec.

25-27. American Standards Assn., 11th National Conference on Standards, Sheraton-Atlantic Hotel, New York, N. Y.

25-28. National Assn. of Corrosion Engineers, South Central Regional Meeting, Mayo Hotel, Tulsa, Okla.

26-27. Illinois Institute of Technology, 1960 Computer Applications Symposium, Morrison Hotel, Chicago, Ill.

28. American Institute of Chemical Engineers, South Texas Section, 15th Annual Technical Meeting, Rice Hotel, Houston, Tex.

31. American Management Assn., Packaging Management Course, Hotel Astor, New York, N. Y.

November

2-4. Society for Experimental Stress Analysis, Annual Meeting, Berkeley, Calif.

3-4. American Production and Inventory Control Society, 3rd Annual National Conference and Technical Exhibit, Sheraton-Cadillac Hotel, Detroit, Mich.

7. Society of Plastics Engineers, "Automation in Injection and Compression Molding", King Edward Sheraton Hotel, Toronto, Ont.

7-9. The Chemical Institute of Canada, Canadian Chemical Engineering Conference, Quebec City, Que.

8-10. The Material Handling Institute, Inc., Material Handling Institute Central States Show, The Kentucky Fair and Exposition Center, Louisville, Ky.

9-10. The Chemical Market Research Assn., Annual Meeting, Pittsburgh Hilton Hotel, Pittsburgh, Pa.

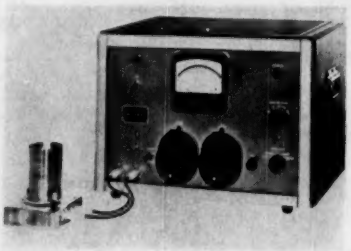
14-18. American Society of Tool Engineers, Western Tool Show & Semiannual Convention, Ambassador Hotel, Los Angeles, Calif.

15-16. Purdue University, Symposium on Engineering Applications of Probability and Random Function Theory, Lafayette, Ind.

(continued from p. 20)

phragm chambers, creating a false sensing condition that automatically compensates for the greater flow.

Diaphragm material is high-temperature, chemical resistant Buna-N-coated nylon. Unit capacities range from 5 cfh. to 10,000 cfh.—**Reeves Brothers, Inc., New York, N. Y.** **70D**



Moisture analyzer

Accuracy and fast response claimed for new instrument.

This compact instrument measures 0-80% moisture either continuously or on a single sample, with an accuracy of 0.01 to 0.5%.

Using a means of radio-frequency power absorption, it completes a test within 10-20 sec. without physically or chemically changing the material. Material density, granular size or process temperature are said to have no effect on accuracy. Calibration must be made with the material to be measured.

A special analyzer of the same type can also be used for systems with two chemical variables.—**Boonton Polytechnic Co., Inc., Boonton, N. J.** **144A**

Photometric Analyzer

New line monitors components in complex gas, liquid streams.

Three photometric analyzers, which can be used to monitor or control absorbing components in process streams, use a variety of

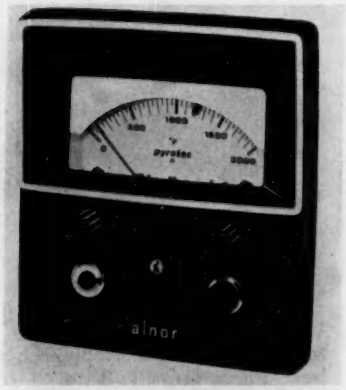
light sources and filters to achieve flexibility in analysis.

Series 500 unit operates in the near-infrared region, alternately passing two narrow bands of radiation through the sample. One wave length is selected where the component of interest has a characteristic absorption band, the other where there is no absorption.

A detector and amplifier provide electrical pulses from the band signals, whose amplitudes are a ratio based on component concentration. The 500 unit is particularly suitable for measuring small quantities of water in various hydrocarbons.

Series 600, operating in the visible and ultraviolet regions, uses a two-beam method where one beam passes through the sample, the other through a reference path. The difference in the amplified signal is a measure of the component concentration. The 600 monitors butadiene and isoprene concentrations in various solvent streams, among other applications.

Series 350 analyzes oxygen in ranges from 0-1% or 0-10% with an accuracy claimed to be ±2% of the reading. — **Analytic Systems Co., Pasadena, Calif.** 144B



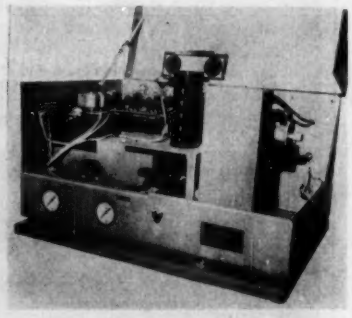
Temperature cutout

Instrument indicates temperature, guards against excess.

Called the Pyrotac, an instrument combines automatic protection against excess temperature

with continuous temperature indication. One model, N-34, will shut off upon line voltage failure; model N-30 will not.

Primarily intended for use with other controllers, the Pyrotac can also serve to shut down a process at a final preset temperature or to signal an operator. Low-temperature cutout is optional. Unit comes in 11 ranges from 0-400 F. to 0-3,000 F., as well as −100 to −300 F.—**Alnor Instrument Co., Div. of Illinois Testing Laboratories, Inc., Chicago, Ill.** 145A



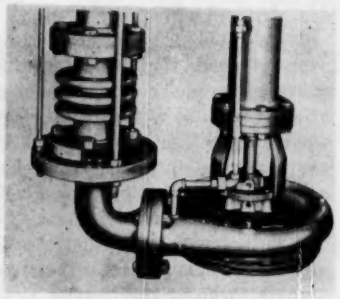
Flame photometer

Continuous unit detects impurities in process streams.

Measurement of elements in process streams is now possible on a continuous basis with the new Flame Photometer. It consists of an optical unit and a control panel, may be supplied with a single or multipoint manifold system.

In operation, a sample stream is selected in sequence and fed to the burner unit, which is supplied with hydrogen and oxygen in precise ratio. When an emitting impurity (sodium, potassium, nickel, copper, iron, etc.) is present in the sample, the flame emits the characteristic radiation of that material. The radiation is converted to voltage that is amplified and measured in the control unit to detect the type and quantity of impurity.

The new instrument has particular application for studying leakage in heat exchangers and condensers. — **Waters Associates, Framingham, Mass.** 146A



Steam-jacketed pump

Vertical unit maintains temperature of viscous liquids.

To prevent the loss of heat content and preserve the fluidity of viscous liquids, a new vertical centrifugal pump, as well as pipe column and discharge pipe, is steam jacketed.

Steam connections are located above the cover plate to prevent any possibility of contamination of the product with steam. For long lengths of vertical discharge piping, an expansion joint is provided to allow for unequal expansions due to temperature differences.—**Goulds Pumps, Inc., Seneca Falls, N. Y.** 146B

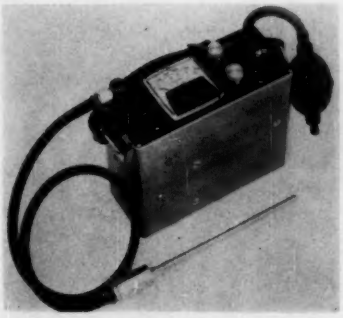
Space heater

Furnace on wheels produces hot, fresh air in large volume.

Similar to an oil furnace, a new, portable space-heater blows air around the outside of a completely enclosed combustion chamber to produce heated fresh air in volume. Fumes are vented out the top to meet safety specifications.

Built-in devices are said to make the operation safe and automatic. Room thermostat permits selection of desired temperature. Should the power go off or the thermostat be turned off, the fire goes out immediately. Low oil level similarly cuts off the flame, which is ignited automatically without torch or match.

Model S-200 puts out 200,000 Btu. per 1,600 cfm. warm air; Model S-420 yields 420,000 Btu. at a rate of 4,500 cfm. air. No attendant is necessary for such applications as heating warehouses or loading docks, or for warming up or thawing equipment.—**Stow Mfg. Co., Binghamton, N. Y.** 146C



Gas detector

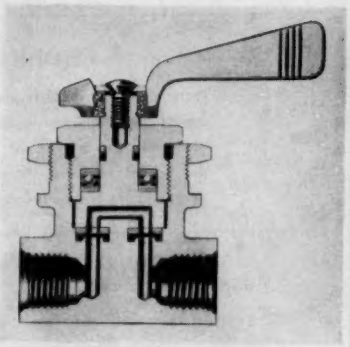
Sensitive unit sniffs hydrocarbon vapors, warns of toxicity.

Toxic or flammable vapors ranging as low as 10 ppm. are sniffed out by a new aromatic hydrocarbon indicator, which is calibrated on benzene but provides conversion factors in tabular form for many other hydrocarbons. It may also be calibrated at the factory for specific vapors.

The unit is powered by nickel-cadmium batteries designed to last the life of the instrument. A built-in trickle-charger, with recessed terminals in the end of the indicator case, is provided to maintain the batteries at full working power. — **Johnson-Williams, Inc., Palo Alto, Calif.** 147A

More Equipment on p. 149

NEW EQUIPMENT . . .



Miniature valve

3,000-psi. selector valve for pneumatic and hydraulic service.

Suited for panel-mounted pilot control, instrumentation, and pressure gage selection, a new directional-flow valve has microfinish sliding seals that are wear-compensating, wiping the surfaces clean as they move across the ports.

Equipped with a new handle designed to give better panel clearance and increased leverage, miniature valve is available in 2-, 3- and 4-way styles in ⅛- and ¼-in. sizes.—**Republic Mfg. Co., Cleveland, Ohio.** **149A**

Briefs

Gas density instrument will continuously measure and record variations in process stream density. Typical application is monitoring composition of two-component stream where media have substantially different densities. — **Beckman Scientific and Process Instruments Div., Fullerton, Calif.** **149B**

Invisible sound barrier is created by thin, transparent panels of laminated safety glass made with polyvinyl butyral plastic sheet. Plastic layer effectively cancels many sounds in the 1,000 to 4,000 cycles/sec. range, renders nearby conversations unintelligible. — **Plastics Div., Monsanto Chemical Co., Springfield, Mass.** **149C**

Clear away snow and ice from concrete steps around outside equipment with new step-heater mats that can be incorporated right into the steps when they are poured. Unit heats a section 8 × 36 in. on each step, consists of heating cable interwoven with lightweight galvanized mesh.—**Edwin L. Wiegand Co., Pittsburgh, Pa.** **149D**

Ball valve has no bonnet, gasket or joints, uses principle of rotating seats, is compact and lightweight. It may be installed in any position, will work with automatic operators of all types. Sized from 2 to 36 in. for 150-600-psi. ASA classes, 2 to 6 in. for 1,000-5,000-psi API classes. — **Cameron Iron Works, Inc., Houston, Tex.** **149E**

Automatic filling machine forms, fills and seals pouch-type containers for liquids, creams and pastes. Makes containers from cellophane, foil, pliofilm, polyethylene or laminated combinations, fills up to 288 packages/min.—**Speedway Machine and Tool Co., Inc., Indianapolis, Ind.** **149F**

Equipment Cost Indexes . . .

	Mar. 1960	June 1960
Industry		
Avg. of all	237.8	238.2
Process Industries		
Cement mfg.	232.4	232.8
Chemical	240.0	240.1
Clay products	225.8	226.2
Glass mfg.	226.6	226.6
Paint mfg.	229.7	229.8
Paper mfg.	231.3	231.3
Petroleum ind.	234.7	234.1
Rubber ind.	237.5	237.6
Process ind. avg.	236.3	236.5
Related Industries		
Elec. power equip	242.8	242.7
Mining, milling	241.5	241.5
Refrigerating	268.4	268.5
Steam power	224.9	225.0

Compiled quarterly by Marshall and Stevens, Inc. of Ill., Chicago, for 47 different industries. See Chem. Eng., Nov. 1947, pp. 124—6 for method of obtaining index numbers; April 4, 1960, pp. 149-50 for annual averages since 1913.

Technical Bookshelf

Chemicals & Materials

From all of the recently published technical books, here's a gleaning of those devoted to individual chemicals and materials. Our comments are noncritical, capsule reviews suggesting scope of the books' contents. Purpose is to alert you and all chemical engineers to the availability of these new monographs.—HSG

"Salt was the world's first article of commerce."

The chief chemical engineer of International Salt Co. draws on three decades of experience to fill a vacant niche. No other publication—here or overseas—completely covers the broad general field of salt technology: production, properties and uses. Increase in annual consumption in the U. S. to 25 million tons reflects not food consumption but the growing industrial importance of this chemical and raw material. Dr. Kaufmann's opus will be welcomed by everyone: users and producers, consumers and engineers. (Sodium Chloride. Edited by D. W. Kaufmann. Reinhold Publishing Corp., New York. 743 pages. $20.)

"Whole industries have been based upon carbohydrates."

Volume five in "The Chemistry of Natural Products" series, book serves as a handy guide to structural formulas, is written in concise outline style. (The Carbohydrates. By S. F. Dyke. Interscience Publishers, Inc., New York. 232 pages. $4.75.)

"Without glass, science would be blind."

Intended for "users rather than manufacturers of glass products," author presents clearcut discourse on the subject. Book is well laid out, chapters progress in easy-to-follow sequence, include sections on the chemical industry and special classes and applications. (Glass—Its Industrial Applications. By C. J. Phillips. Reinhold Publishing Corp., New York. 252 pages. $6.95.)

"World consumption is probably over* 200,000 *tons/annum."

Pointing up the great strides recently taken by fluorine research and technology, the editors have come up with the first of a series intended to explore these advances. The five sections: halogen fluorides, transition metal fluorides, fluoroboric acids, the electrochemical process for the synthesis of fluoro-organic compounds, exhaustive fluorinations of organic compounds with high-valency metallic fluorides. One feature: extensive references appended to each section. (Advances in Fluorine Chemistry. Vol. I. Edited by M. Stacey, J. C. Tatlow and A. G. Sharpe. Academic Press Inc., New York. 203 pages. $8.)

"Production of sulfuric . . . barometer of industrial activity."

In this ACS-sponsored offering, twenty-four specialists have contributed monographs covering practically every conceivable phase of H_2SO_4 manufacture. Said to be "the only book in English covering this . . . topic," expert discussions include: present industry trends; handling, storing and shipping; equipment and practices; health and safety measures. New topics are: cost comparisons of the contact process using different raw materials, the treatment of stack effluents, the modern theory of the catalysis in contact converters. (Manufacture of Sulfuric Acid. Edited by W. W. Duecker and James R. West. Reinhold Publishing Corp., New York. 515 pages. $12.50.)

"Safe working conditions for beryllium . . . now established."

The seventh and most recent in the publisher's "Metallurgy of the Rarer Metals" series. Previously covered: chromium, zirconium, manganese, titanium, molybdenum, tantalum-niobium. Book details the metal's properties, discusses current applications. (Beryllium. By G. E. Darwin and J. H. Buddery. Academic Press Inc., New York. 392 pages. $13.50.)

"Bismuth is an effective safeguard against the tin pest."

Properties and applications of an ancient but important metal are thoroughly discussed in this British publication. Electrodeposition chapter examines the chemistry and practice of plating both tin and its alloys. Mining, extraction, refining and tin compounds are outside the scope of this new reference. (Tin and Its Alloys. Edited by E. S. Hedges. St. Martin's Press, New York. 424 pages. $27.50.)

"The commercial status of magnesium . . . has been established."

Latest in a series on "The Science and Technology of Materials," the book's nine sections treat: physical properties, alloy theories and properties, magnesium alloy systems, deformation, time-temperature-dependent alloy phenomena, casting alloys and technology, wrought alloys and technology, chemical properties and applications, extraction and refining of magnesium. (Magnesium and Its Alloys. By C. Sheldon Roberts. John Wiley & Sons, Inc., New York. 230 pages. $9.)

"The actual history of polythene began in 1932 . . ."

Comprehensive British text on the subject is now out in a second edition. Revision adds about 300 pages; recasts earlier data, particularly that on higher-density materials; includes a table of world manufacturers, their production capacities. (Polythene. 2nd Edition. Edited by A. Renfrew and P. Morgan. Interscience Publishers Inc., New York. 781 pages. $25.75.)

*"Plutonium is destined to outstrip uranium-*235 . . ."

Here's the very first book dealing solely with plutonium metallurgy. Thirty-two authorities contributed to a symposium in San Francisco last year. Their papers have been edited and the results of 15 years of research are now available. (Extractive and Physical Metallurgy of Plutonium and Its Alloys. Ed. by W. D. Wilkinson. Interscience Publishers, Inc., New York. 314 pages. $10.50.)

"The first organosilicon compound was made in 1863."

Chemistry of the organosilicons is thoroughly reported in this recent British publication. Chemists and research workers will appreciate the experimental methods presented and the copious references to original publications (through 1958). (Organosilicon Compounds. By C. Eaborn. Academic Press, N. Y. 530 pp. $15.)

"Fats are also produced by certain bacteria, molds and yeasts."

From almond oil to whale oil, this small book successfully adheres to its original purpose of merely outlining the fundamentals of the chemistry and technology of animal and vegetable fats and oils. Appendixes give tabulated data, a glossary and listing of other reference sources. (Fats and Oils. 2nd edition. By H. G. Kirschenbauer. Reinhold Publishing Corp., New York. 240 pages. $7.)

"Mixture of good properties rather than one outstanding . . ."

Latest in Reinhold's Plastics Applications Series, this small book describes properties, manufacture, applications, foam and future prospects of polystyrene. Primarily directed to molders, fabricators and end-users. (Polystyrene. By W. C. Teach & G. C. Kiessling. Reinhold Publishing Corp., New York. 176 pages. $5.)

Letters: Pro & Con

Speechmaking: Con

Sir:

In my opinion, widespread acceptance of the speechmaking philosophy expressed by W. A. Sylvester (Aug. 8, pp. 143-144) would set industrial oral communications back by 25 years.

Sylvester's statement, "Criterion of success for a technical talk is not whether people enjoyed it, but whether certain people approved of it," is absurd. Is he suggesting that a speaker's main objective should be to make a grandstand play to one or two individuals whose presence at the meeting may not even be predictable? If a presentation is good, word will get around to the proper individuals. Success speaks for itself.

Author Sylvester admits the desirability of good technique but seems to feel that unless a person is born with it (and who is?) he should just give up and not waste his time trying to improve his delivery. I wonder how many good projects have failed to win approval simply because a good technical man lacked the communication skills to sell his ideas to others.

A vote of confidence to Lawrence Murphy for his fine article (Apr. 4, pp. 151-154) and to the editors of *Chemical Engineering* for printing both viewpoints.

KENT WILLIAMS
Standard Oil Co. (Ohio)
Cleveland, Ohio

Speechmaking: Pro

Sir:

Just a few words to let you know how much we appreciated Mr. Sylvester's two essays, "Beware of the Expert Speech Makers" and "How to Sound Like a Manager."

MIKE HECHT
Chicago Carton Co.
Chicago, Ill.

Speechmaking: Con

Sir:

With a great deal of interest and a rising surge of indignation, I read Mr. Sylvester's article in your Aug. 8 issue. While I'll admit that dramatic speech-making can be carried to an extreme, this article has gone completely overboard.

Most experts in this field, if they're really doing their jobs, have no interest in jazzing up a technical speech for the sake of dramatics. But perhaps they can help distinguish between words written to be spoken aloud and words written to be read silently.

Secondly, the speech expert can help the novice overcome, or at least minimize, those distracting habits most nonpracticed speech givers are victims of—shifting feet, monotonous tone, unorganized thoughts (for speaking), etc.

To be sure, the listeners are interested primarily in the content of a technical talk. But being human, they want to receive that content in as painless a process as possible. So—

- Why not remember both your engineering and your audience?
- Why not organize your technical matters so that they can best be understood by a listener?
- Why not eliminate burdensome details that only slow your speech down without being retained by the audience?
- Why not learn a few basic gestures that will make you look less like a totem pole and more like an intelligent human being?

Incidentally, it's good to see your fine publication getting involved in such subjects. Keep it up.

ROBERT J. BARRUS
Jefferson Chemical Co.
Houston, Tex.

Pro: Binding and Layout

Sir:

May I offer a belated word of appreciation for your present binding and layout?

I recently faced a two years' accumulation of back numbers of *CE* piled up, waiting for me to extract articles for my files. Part of the pileup was due to lack of time, but much of it was caused by reluctance to tackle the job of removing staples and tearing apart sections to get at what I wished to save.

And then, starting with the 1959 issues, I discovered the tremendous improvements you had made. The rest of the job was a breeze, and now I keep up to date by removing articles as I go through each new issue of the magazine.

These improvements have, in my opinion, put an already fine publication far ahead of any similar technical magazine. Please accept the sincere thanks of one delighted subscriber.

GEORGE F. DALE

Radford, Va.

Con: Pay Reductions

Sir:

In your July 11 issue (p. 142) you refer to "pay cuts" imposed by Standard Oil Co. of California on its executives. This is wholly incorrect, since there have been no pay cuts for many years.

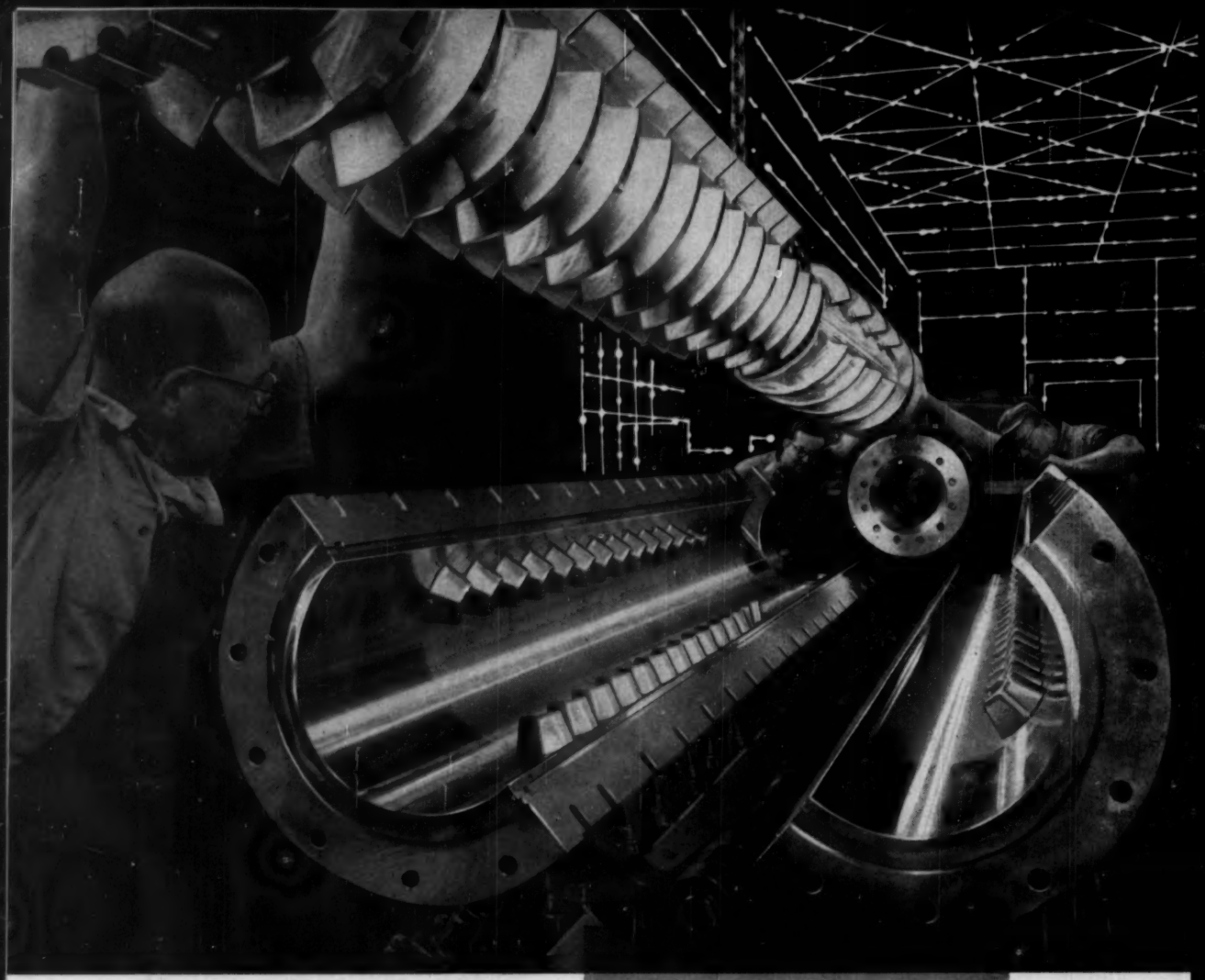
To clarify the record: salary levels continue the same in 1960 as they did in 1959 and in preceding years. There has been no general reduction as a result of lower profits in 1959 or for any other reason.

The reduced 1959 compensation levels which you reported resulted from a lower company contribution to the employees' stock purchase plan. However, this contribution is paid into a trust fund, not directly to employees, and an employee may not withdraw his share of the company contributions until age 60 or later. The stock plan contribution, therefore, is in no sense a part of anyone's salary but is, rather, a fringe benefit designed to attract and keep career employees.

Salaries paid to our employees in the current year, as well as in preceding years, are competitive with those paid elsewhere in our industry. We are concerned that potential employees may otherwise conclude from your article that our company's pay structure is less attractive than that of other firms.

S. Z. NATCHER

Standard Oil Co. of California
San Francisco, Calif.



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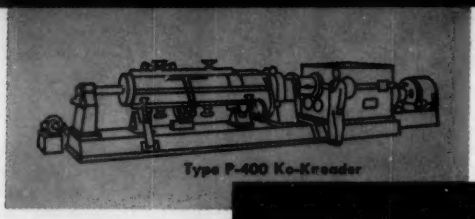

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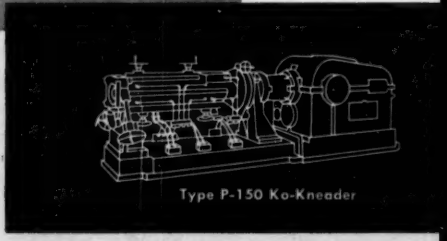

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4	17-25f	55a	65	80	138	146C	154	159E	162A	164E	167	170B	172C	173L
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8	28	55c	67	82	140	147A	158b	160A	162C	165	168A	BL171	172E	T174
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9-11b	30	59	68B	84	142	149A	158d	160C	163A	165B	169	R171b	173A	TL184
12	31	60A	68C	115	143	149B	158A	160D	163B	165C	169A	171A	173B	TR184
13	32	61	68D	120	144A	149C	158B	160E	163C	165D	169B	171B	173C	B184
14-15a	34	62A	69	124	144B	149D	158C	160F	163D	165E	169C	171C	173D	185
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Chemicals

Acetonitriles.....Claimed to be a complete source for acetonitriles, this 56-page guide book contains reactions, properties, specific uses, and a 134-reference listing.
158A Sohio Chemical Co.

Activated Carbon.....purifies liquids & gases, recovers solvents, and catalyzes & serves as a catalyst support. Literature Group J-46 available for details.
139 *Barnebey-Cheney

Aliphatic Organics.....This 12-page catalog covers specifications of more than 200 fatty acids and fatty nitrogen derivatives and shows typical applications.
158B Armour Industrial Chem. Co.

Chelating Agents.....Versene 100 and Versenex 80 are both broad-spectrum chelating agents forming complexes with the same metal. Descriptive literature.
9-11b *The Dow Chemical Co.

Chemicals Catalog.....12-page revised edition lists more than 600 chemicals and includes a great number of unusual compounds as well as many commercial chemicals.
158C Aceto Chemical Co.

Citric Acid.....Brochure contains information on physical and chemical properties and gives extensive information on application for food, pharmaceutical and industrial use.
158D Miles Chemical Co.

Coating.....An air dried protective coating that cures at room temperature and resists high temperature brine, caustic solutions and solvents is described in bulletin.
158E Wisconsin Protective Coating Corp.

Dihydropyran.....is a colorless, mobile liquid of ether-like odor. Bulletin 137 describes many of its reactions, and gives references. Available now.
55a *The Quaker Oats Co.

* From advertisement, this issue.

LITERATURE . . .

Diisocyanates.....The Handling and Storage of Toluene Diisocyanates are covered by detailed text & diagrams in a new manual which is available.
61 *Allied Chem., Nat'l. Aniline

Diisocyanates.....History and chemistry is given in booklet that tells how materials containing active hydrogen atoms will combine with diisocyanates to give urethanes.
159A National Aniline Div.

Ferrites.....Survey of ferrite materials discusses and illustrates "soft" ferrites, "hard" ferrites (permanent magnets) and ferrites used in memory products.
159B Indiana General Corp.

Filter Aid.....Solka-Floc is completely non-abrasive to extraction equipment. For filtration problems in food processing, chemicals, pharmaceuticals & other fields. Folder.
159 *Brown Company

Fluorosilicone Rubber.....Brochure describes solvent resistant material that adds up to a real design aid wherever fuels, oils or solvents must be taken into consideration.
159C Dow Corning Corp.

Graphite.....Booklet presents special characteristics of manufactured graphite products. Also some of the important applications for which these products are being used.
159D Great Lakes Carbon Corp.

Ion Exclusion.....is a branch of ion exchange chemistry notable for the efficiency & simplicity of its action. Complete information in Dowex Ion Exchange Book.
9-11a *The Dow Chemical Co.

Latex.....Resyn 3600, a new polyvinylidene chloride latex has been compiled in the data of a special booklet, Technical Bulletin 340, available on request.
159E National Starch and Chemical Corp.

Metal Fluorides.....There are 17 metal fluorides for your research or process needs. Samples, prices and technical data on any of them is available.
39 *Allied Chem., General Chem. Div.

* From advertisement, this issue.

Want to build up your files and keep them up-to-date? You can get any publication in this comprehensive guide — free — just for the asking.

It's easy — simply circle item's number on the Reader Service Postcard and mail. Replies will come directly from companies offering the literature.

LITERATURE . . .

Methanol.....Almost anything that you need to know about methanol is included in this 36-page brochure of data on properties, uses, handling, shipping and storage.
160A Commercial Solvents Corp.

Methylfuran.....is a cyclic dienic ether which merits attention as a chemical intermediate. It is infinitely miscible with most organic solvents. Bul. 135.
55b *The Quaker Oats Co.

Methyltetrahydrofuran.....is a cyclic ether useful in organic synthesis, and may also have value as a reaction solvent. Additional information in Bul. 136.
55c *The Quaker Oats Co.

Plastic.....Seilon offers a complete line of corrosion resistant thermoplastic sheet materials . . . available in stock sheets 4′ x 8′ from ¼″ through 1″ in thickness.
141 *Seiberling Rubber Co.

Plastic Shapes and Parts.....Included in this 16-page catalog are units manufactured from Teflon, C.T.F.E., Delrin, Nylon and many other resins as well.
160B Garlock Inc.

Protein Hydrolysates.....Fermentation media components, available in commercial quantities, are described in data sheets that include nitrogen and amino acid analysis.
160C Amber Laboratories, Inc.

Rare Earth Metals.....24-page brochure describes and defines properties of sixteen high-purity rare earth metals that can be applied as scavengers and alloying agents.
160D Lunex Co.

Slime Control.....Data sheet "Slime Control with Chlorine and Non-Oxidizing Biocides" discusses how the judicious use of above chemicals will extend cooling tower life.
160E Betz Laboratories, Inc.

Super Alloy Tubing.....Bulletin describes metals that have a 1000 hour stress rupture strength at 1200 F. at 25,000 psi minimum stress and show corrosion resistance.
160F Superior Tube Co.

Surface Coating Resin.....Bulletin gives physical properties, compatability and applications of Buton resins, a new line based on butadiene-styrene polymers.
160G Enjay Chemical Co.

Surfactants.....16-page brochure contains graphic and tabular data on properties of Triton nonionic surface-active agents and includes many application illustrations.
160H Rohm & Haas Co.

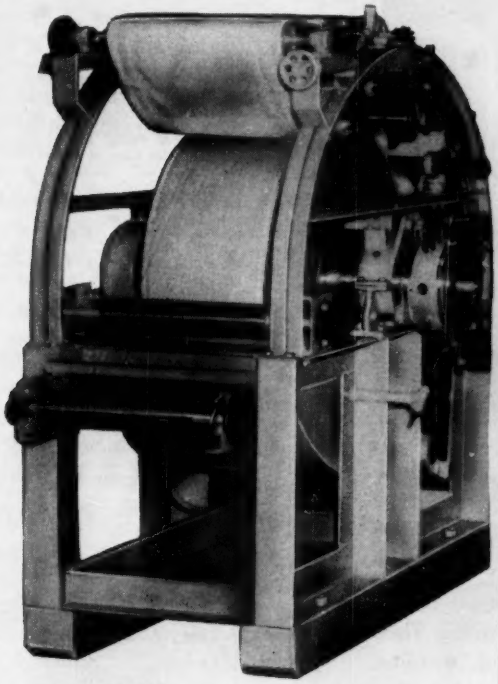
Teflon.....Pamphlet contains tables and descriptive matter on chemical, electrical and mechanical properties. Includes stock list with standard dimensions.
160I Fluoro-Plastic, Inc.

Wood.....Brochure outlines the history, applications and mechanical properties of EKKI wood. It is resistant to marine borers, fungi & decay, acids, abrasion, etc.
160J Ichabod T. Williams & Sons, Inc.

Vacuum Melted Metals.....Data book on consumable electrode method of vacuum melting super alloy steels includes information on advantages of metals produced this way.
160K Midvale-Heppenstall Co.

* From advertisement, this issue

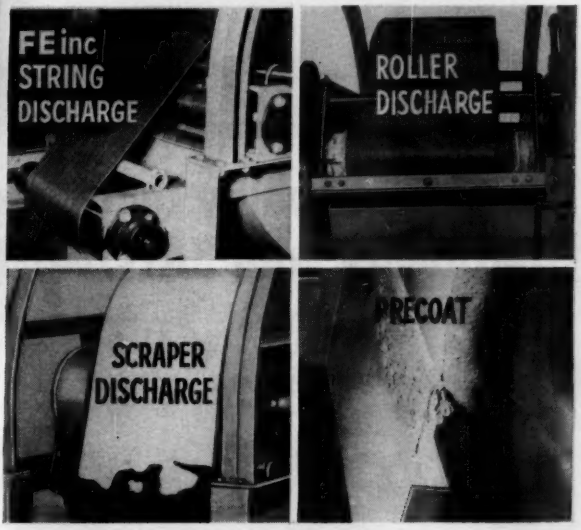
Which pilot plant filter do you need?

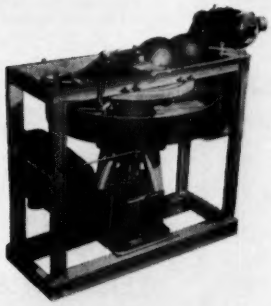


DRUM FILTER — String, scraper, roller, belt and precoat discharge can be tested on the extremely flexible FEinc Pilot Plant Drum Filter. Submergence washing and compression dewatering mechanism can be utilized if desirable. The 3 x 1 ft. size has 9.4 sq. ft. of filtering area and is constructed of Type 316 stainless steel. Smaller sizes available.

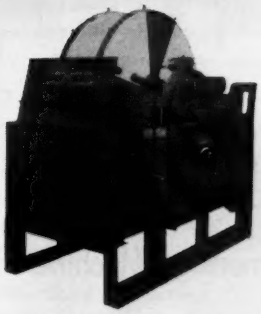
Eliminate the risk and unnecessary capital investment by scaling up from one of the seven Pilot Plant Filters offered by FEinc.

Available on a rental basis, these units allow you to determine optimum design and operation conditions for maximum filtering efficiency in your particular process. See our insert in Chemical Engineering Catalog, or write for bulletins or technical advice without obligation. Address Dept. CEF-1060.





HORIZONTAL FILTER — FEinc can supply pilot models of both open and enclosed horizontal filters. 3 ft. diameter. Type 316 stainless steel. 7.6 sq. ft. filtering area.



DISC FILTER — FEinc Disc Filters for pilot plant work are also available. All FEinc pilot models are supplied with the filter cloth determined best for the application.

FE INC®

FILTRATION ENGINEERS DIVISION OF
American Machine and Metals, Inc.
East Moline, Illinois

Custom-designed continuous vacuum or pressure filters for better cake quality . . . lower costs . . . maximum filtering efficiency

Divisions of American Machine and Metals, Inc.

TROY LAUNDRY MACHINERY • RIEHLE TESTING MACHINES • DE BOTHEZAT FANS • TOLHURST CENTRIFUGALS • FILTRATION ENGINEERS • FILTRATION FABRICS
NIAGARA FILTERS • UNITED STATES GAUGE • RAHM INSTRUMENTS • LAMB ELECTRIC COMPANY • HUNTER SPRING COMPANY • GLASER-STEERS CORPORATION

LITERATURE . . .

Construction Materials

Insulation.....New 6-pg. brochure lists pertinent data concerning Calcium Silicate Pipe & Block Insulation for temperatures up to 1350 degrees Fahrenheit.
162A Philip Carey Mfg. Co.

Cements.....A complete line of sulfur silicate & resin based cements for plant-wide use in constructing corrosion-proof tanks, floors, pits, trenches & sumps. Bul. CC-3.
L170a *Atlas Mineral Products Co.

Ceramic Catalyst Carriers.....Size, weight, porosity, & purity are held to close tolerance. Carriers are described in detail in bulletin "Keys to Better Catalysis".
65 *Norton Company

Insulating Cement.....Super "66" insulating cement for temperatures up to 1800 F. Contains a special rust inhibitor that actually prevents corrosion.
82 *The Eagle-Picher Co.

Packings.....Braided Teflon packings are available in all sizes in standard $\frac{1}{16}$" increments from $\frac{1}{8}$" to $\frac{3}{4}$" square . . . in spool or coil forms. Revised Bul. CP-552.
150 *Chemical & Power Products, Inc.

Plastic Structures.....Corrosion-proof, self-supporting polyvinyl chloride designed & fabricated for use as tanks, duct & fume systems to meet your exact needs. Bul. CC-3.
L 170c *Atlas Mineral Products Co.

Tank Linings.....natural or synthetic rubber and asphaltic materials designed to meet specific corrosive conditions within your plant. Bulletin CC-3.
L170b *Atlas Mineral Products Co.

Vacuum Melted Steels & Alloys..... A copy of "Modern Melting at Allegheny Ludlum" is offered. Gives technical data on the new melting techniques & quality improvements.
129 *Allegheny Ludlum Steel Corp.

Wire Cloth.....For corrosive service, cloth with accurate mesh count, close tolerance wire diameter, precision weaving, etc. Bulletin F-C has details.
140 *Newark Wire Cloth Co.

Zinc Dust.....is now being used as a reducing agent, precipitating agent, purifier, catalyst, polymerizing agent, & in rust-resistant paints, bleaches, etc. Information.
124 *American Smelting & Refining

Electrical & Mechanical

Electrical Power Systems.....for missiles, satellites and space vehicles. Bulletin discusses solar termionic, photovoltaic cell, fuel cell, nuclear reactor etc. power systems.
162B General Electric Co.

Gas Turbine Generator.....The economics of gas turbine power generation for U. S. Defense sites and for commercial applications are discussed in Bulletin 202.
162C Clark Bros. Co.

* From advertisement, this issue.

LITERATURE . . .

Magnetic Starters.....Brochure 14-Ba describes new design magnetic starters featuring unitized construction with all components front removable.
163A Furnas Electric Co.

Motor Selection Guide.....A 3x7 inch pocket-size card provides quick reference to frame size and book price for a-c motors from ¾ to 125 horsepower.
163B General Electric Co.

Motors.....For totally-enclosed, open-type & Super-Seal general purpose motors, & electrically or mechanically modified definite-purpose motors. Application help available.
63 *Allis-Chalmers

Motors.....Custom '800' are manufactured to rigid quality specifications. Information on these motors in chemical industry contained in Bul. GEA-6855 & GEA-6889.
148 *General Electric Co.

Motors.....Folder SE-L2604 contains tech. characteristics, specifications, ratings & outline dimensions of new 50, 150 & 250 ounce-inch Slo-Syn Synchronous Motors.
163C The Superior Electric Co.

Silicon Rectifier Units.....are perfected & specifically designed for fast, simplified conversion of existing mechanical or tube rectifiers. Details of unit offered.
4 *Buell Engineering Co.

Speed Reducers.....with new worm hardness pattern which gives maximum thread strength and resistance to wear. Latest developments in Bulletin No. 405.
59 *Cleveland Worm Gear

Starters.....Custom file covers standard and custom starters and starter generators from 75 amp to 400 amp, as well as direct cranking electric starters.
163D Breeze Corp. Inc.

Transformers.....Range of liquid filled substation transformers covered in 16-page bulletin is single and three phase, 501 to 10,000 kva, and up to 69 kv.
163E I-T-E Circuit Breaker Co.

Unilet.....New explosion-proof 90 degree pulling Elbow Unilet with roller action available. Unilets in 2½" to 4" sizes with rollers, 1" to 2" sizes less rollers.
1 *Appleton Electric Co.

Handling & Packaging

Feeders.....are suspended from the feed bin which eliminates costly feeder support structure, provides accessibility to equip. & requires low head room. Bul. 33-E-11.
186 *Hardinge Co.

Hinged Closures.....New design features & extended sizes ranges for the line of one-man hinged closures are described in a revised Bulletin TT956.
163F Tube Turns Div., Chemetron Corp.

Industrial Weighing Equipment..... Information on the full line of industrial weighing equipment from 1/100 oz. to 100 tons is available on request.
TL171 *Detecto Scales, Inc.

* From advertisement, this issue.

LITERATURE . . .

Low Temperature Storage.....8-page brochure describes the design and function of facilities for the storage of liquified gases between +32°F and —50°F.
164A Chicago Bridge & Iron Co.

Winches, Hoists.....Catalog gives application, construction and special features plus drawings of rescue hoists, heavy duty cargo hoists, combination winches etc.
164B Breeze Corp. Inc.

Heating & Cooling

Air Conditioning & Refrigeration..... Equipment handles loads between minus 150 & plus 100 degrees F. Booklet explains service in chemical industry.
173 *Frick Company

Electric Strip Heaters.....for heating tanks, kettles, pipes, platens, dies, ovens. In shapes, sizes & wattages to fit hundreds of industrial heating needs. Bul. PA100.
29 *Edwin L. Wiegand Co.

Heat Exchangers.....The new line of multi-tube, double pipe heat exchangers is described in their new Bulletin 111. Explains design features & applications.
164C Brown Fintube Co.

Heat Exchanger Tube.....Brochure includes technical information on the use of copper alloy tubes in condensers and heat exchangers. Also chart of tube alloys.
164D Scovill Mfg. Co.

High Temperature Torch.....Model F-5000 Torch is adaptable for a laboratory instrument or as a completely engineered system for pilot plant installation.
164E Thermal Dyanamics Corp.

Packaged Boilers.....are completely pre-engineered and tested as a package. Sizes through 600 hp . . . oil, gas & combination oil-gas firing. Details in booklet.
128 *Cleaver-Brooks Co.

Panelcoil.....Technical data sheet 15-60 series gives complete engineering and cost data on Dean Panelcoil. Price Bulletin 259 also available.
T152 *Dean Products, Inc.

Plate Heat Exchangers.....Delaval Plate Heat Exchangers require a lower pressure drop than shell-and-tubes. Additional information in booklet.
14-15c *The De Laval Separator Co.

Instruments & Controls

Air Pollution Control.....Bulletin describes and gives application and operation of instrument designed to monitor and record low concentrations of sulfur dioxide in the air.
164F Beckman Scientific

Control Centers.....A-B control centers are readily adaptable to changing needs. Individual units can be added or modified without internal rewiring. Bulletin 798.
67 *Allen-Bradley Co.

* From advertisement, this issue.

LITERATURE . . .

Flow Meter.....Bulletin describes high pressure flow indicators and alarms designed to operate at pressure up to 1,500 psig and to handle flow in ranges from 1.5 to 50 gpm.
165A Brooks Instrument Co.

Flow Meter.....Bellows flow meter models are available in many ranges for both flow & liquid level measurement & control. Details & reference data Catalog C22-1.
26-27 *Minneapolis-Honeywell

Flow Meter.....Catalog C295-1 uses vortex-velocity principle for measuring liquids and gases. Meter may be combined with a densitometer to measure mass flow.
165B Minneapolis-Honeywell Co.

Gas Regulators.....Oxweld industrial regulators and portable manifolds are described and illustrated in catalog that includes specifications and ordering information.
165C Linde Co.

Gauges.....Liquidometer Gauges enable one man to read liquid levels safely & precisely. Type available for practically every liquid measuring application. Details.
165 *The Liquidometer Corp.

Gravitometer.....Details given in booklet on instrument that makes continuous measurements of specific gravity of flowing liquids from within a 40° API range.
165D Central Scientific Co.

Liquid Level Controls.....Booklet describes displacement type liquid level controls for actuating pumps, valves or high and low level alarms in wide or narrow ranges.
165E Magnetrol, Inc.

Magnetic Flow Meter.....has no flow restrictions of any type . . . nothing to plug up. Full details on the high-accuracy, low maintenance of Meter contained in Bul. 20-14.
83 *The Foxboro Co.

Material Level Control.....Catalog sheet gives construction features of electronic unit used to determine presence or absence of material at a selected level in a bin.
165F Flo-Tronics Inc.

Meters.....Type 316 stainless steel meter for measuring liquid fertilizer & corrosive chemical solutions. Many features covered in descriptive literature.
B184 *Badger Meter Mfg. Co.

Pressure Gauge.....The direct-drive helical bourdon gauge offers pressure ranges from 0-1000 to 0-10,000 psi. Additional information can be found in the general catalog.
143 *Rochester Mfg. Co., Inc.

Pressure Instruments.....Complete line is described and illustrated in bulletin. Measuring mechanisms, indicators, recorders and transmitting devices are included.
165G Bailey Meter Co.

Strain Gages.....Catalog contains price information and technical specifications for over 350 types of strain gages plus complete line of instruments and accessories.
165H Baldwin-Lima-Hamilton Corp.

Thermometers, Dial.....are thoroughly dampened with silicone on the bimetal elements & a special precision-machined bearing on the shaft. General Catalog.
142 *Rochester Mfg. Co., Inc.

* From advertisement, this issue.

LITERATURE . . .

Thermocouples.....Well detailed Buyers' Guide and Users' Manual outlines applications, catalogs specifications and gives thermocouple calibration data.
166A The Bristol Co.

Transmitter.....The Sensaire is available in 3 range spans. Ambient case temperature limits minus 30 degrees to +150 F. Air consumption 0.4 scfm. Bul. 98293.
72 *Taylor Instrument Co.

Viscometers.....New Bulletin No. V-1230 describes Viscometers for atmospheric pressure applications. Covers the principle of operation and other features.
166B Norcross Corp.

Pipe, Fittings, Valves

Expansion Joints.....Catalog 56 contains complete & comprehensive engineering data for expansion joints from 3" to 50' diam., pressures to 3600 psi, temp. to 1600F.
45 *Zallea Brothers

Fittings, Flanges & Unions.....Folder PF-1 contains complete data on quantities & weights of the items as packaged in various sizes of cartons.
84 *Henry Vogt Machine Co.

Pipe.....Saran Lined Pipe, fittings, valves and pumps are available for systems operating from vacuum to 300 psi, from below zero to 200 F. Information.
80 *Saran Lined Pipe Co.

Pipe, Armored.....and fittings are readily available from inventory in standard 10 to 20-foot lengths, or can be tailored to meet specific requirements. Bul. F R P-1.
53 *Haveg Industries, Inc.

Piping.....Bondstrand is available in sizes from 2" through 8" with all necessary couplings & fittings. Bulletin containing complete data, including physical properties.
135 *Amercoat Corp.

Valve.....A catalog sheet describing a new pressure reducing & relief valve includes valve drawings, capacity charts, valve features, operating, applications, etc.
166C Atlas Valve Co.

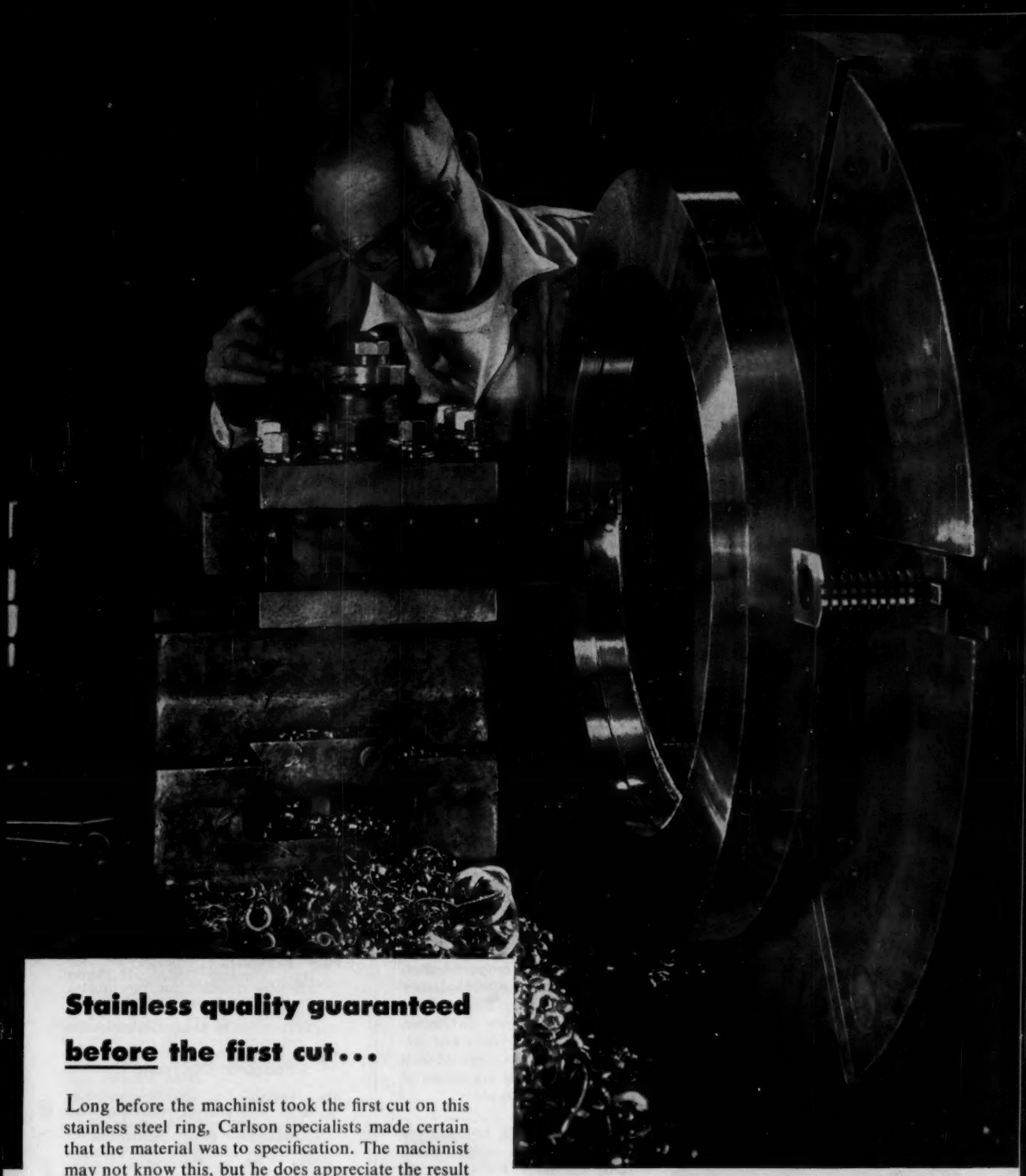
Valve.....New Sampling Valve cannot clog. Designed for simple installation in existing systems, merely by welding a ¾" half coupling into the pipe or vessel.
TR184 *Strahman Valves, Inc.

Valve.....The Penton coated diaphragm valve is available in ½" to 6" sizes; manual or mechanical operators. Additional information in Bulletin 800C.
R171a *W. S. Rockwell Co.

Valve.....with body in wide choice of plastics. Soft rubber or elastomer plunger seals off fluid flow. Sizes 1" to 2". Bulletin 802D available.
R171b *W. S. Rockwell Co.

Valves.....“Flocontrol” valves feature the V-port disc which insures proportional flow throughout the entire lift of the stem. Additional details on request.
30 *Manning, Maxwell & Moore, Inc.

*From advertisement, this issue



Stainless quality guaranteed **before** the first cut...

Long before the machinist took the first cut on this stainless steel ring, Carlson specialists made certain that the material was to specification. The machinist may not know this, but he does appreciate the result —the ease of machining to meet the most exacting requirements.

Whether you want rectangular stainless plates, pattern-cut special shapes, or machined products, you will save fabricating time by making full use of Carlson services. Fabricators of chemical, process, nuclear, aircraft and missile equipment recognize the advantages of these services.

Our specialists will be glad to work with you in producing just what you want, delivered on time. Telephone, write or wire for action.

G.O.CARLSON *Inc.*

Producers of Stainless Steel

134 Marshallton Road
THORNDALE, PENNSYLVANIA
District Sales Offices in Principal Cities

Plates • Plate Products • Heads • Rings • Circles • Flanges • Forgings • Bars and Sheets (No. 1 Finish)

LITERATURE . . .

Valves.....Safety Relief valves have a special "O" ring seat seal that stops leakage completely. Available in both Standard & Balanced Bellows design. Bul. 1940.
57 *Manning, Maxwell & Moore, Inc.

Valves.....A total of 7 different UPVC valves for corrosive service are available. Made for socket, threaded or flange connections in a range of sizes.
B174 *Tube Turns Plastics, Inc.

Valves.....Corrosion-Resistant valves are available in a wide selection of materials, to handle practically every known corrosive media. Details on request.
49 *The Wm. Powell Co.

Valve Pilot.....Brochure describes differential pilot valve that operates on the difference between two columns of liquid, usually a constant reference and a variable head.
168A Besler Corp.

Valve Reducing.....Pamphlet describes sliding gate and plate pressure reducing valve that is air operated and has a capacity of 50,000 pounds of steam per hour.
168B OPW-Jordan

Valves, Gate.....are made in various alloys, types and sizes for most services . . . and for all pressures. Additional information contained in Catalog No. 57.
147 *Darling Valve & Mfg. Co.

Valves, Pinch.....in rubber, neoprene for corrosion and abrasion. Offer pressures to 150 psi and temperatures to 200 F. They cannot leak or stick.
151 *Mine & Smelter Supply Co.

Valves, Stainless Steel.....New catalog covers valves in the patterns you want, in a choice of alloys that satisfy the requirements of practically all corrosive services.
115 *Jenkins Bros.

Swivel Joints.....US type are designed exclusively for the chemical industry. Can be welded into the line and can be repaired on location with simple tools. Catalog.
69 *Continental-Emsco Company

Tube Expanders.....Series 255 for Heat Transfer Units and Series 270 now standard for tube sheets up to 6" thick are covered in new Bulletin "C".
T172 The Gustav Wiedeke Co.

Process Equipment

Air Separators.....offer precise separation and improve screening. Nine models are available with diameters from 3' to 18'. Additional information in Bul. No. 087.
146 *Sturtevant Mill Co.

Blender.....Tri-Rib for agricultural, mineral or chemical mixing. An illustrated brochure on this new type blender is now available on request.
B152 *Posey Iron Works Inc.

Centrifugal.....Low compact design and exclusive Center Slung suspension enable Batch-O-Matic to handle greater out-of-balance loads with minimum vibration. Details.
162 *American Machine & Metals, Inc.

*From advertisement, this issue

Classifiers, Liquid Cyclone.....are described in a revised 8-pg. brochure. Includes Type FR DorrClone & a description of Siphontrol underflow control. Bul. 2503.
169A Dorr-Oliver Inc.

Converters.....feature the exclusive design of small staggered & tapered cutting knives in the large cylinder. Available in a variety of sizes. Information.
T174 *Mitts & Merrill

Dust Collectors.....Brochure illustrates the basic structure of the "1600" Collector. Handles high temperature and abrasive jobs. Requires almost no maintenance.
169B *Dustex Corp.

Feeders.....Merchen Scale Feeders allow more efficient use of existing plant space. Details on feeders and on the new V-notch chlorinators is available.
137 *Wallace & Tiernan Inc.

Filters.....Operating with process streams from 5 to over 1,000 gal. per minute, Niagara filters can be adapted to automatically process hundreds of materials.
163 *American Machine & Metals, Inc.

Floats, Stainless Steel.....Bulletin contains construction data, application information, shape specifications, weight tables, buoyancy formulas, etc.
TL184 *Chicago Float Works

High Vacuum Distillation Equipment.....Four types of Centrifugal Molecular Stills are illustrated & described in detail in Bulletin 3-1. Available on request.
169C Consolidated Vacuum Corp.

Liquid Extractor.....Brochure describes multistage mixer-settler liquid extractor for pilot plant, plant solution of complex extraction problems.
169D Pennsylvania Tool & Mfg. Co.

Mills & Dissolvers.....Technical Bul. 32-1960 on improved methods of preparing textile printing colors through the use of Mills and Dissolvers is available.
R170 *Morehouse-Cowles, Inc.

Mixers.....Maclellan Mixers in hand & power operated models: 5 qts. to 160 cu. ft. capacities for high volume production or laboratory use. Bulletin X-80.
T144 Daffin Mfg. Co.

Mixers.....The new Model RL Shear-Flow portable mixer emulsifies immiscible liquids and handles viscous materials with ease. Complete information offered.
166 *Gabb Special Products Inc.

Mixers.....A complete line of fluid mixers ranging from fixed-mounted 40 H.P. turbines & heavy-duty propeller mixers to lightweight portables. Handbook.
158a *Eastern Industries, Inc.

Mixers.....Two new bulletins describing the RE Series of top-entering mixers are offered. Bul. B-522 describes closed tank mixers. Bul. B-523 the open tank line.
169E Mixing Equipment Co., Inc.

Mixers.....A full line of Flomix, side drive, tank top, portable and tripod mixers are available. Additional information on all types in Bulletin 531 A.
120 *Nettco Corp.

* From advertisement, this issue.

LITERATURE . . .

Mixer, Portable.....for fluid mixing, in sizes from ⅛ to 3 hp, gear drive or direct drive. A descriptive Bulletin B-520 is now available on request.
190 *Mixing Equipment Co., Inc.

Mixers, Side-Entering.....handle the extra heavy-duty jobs in big tanks. Sizes ¼ to 30 H.P. Further information on this type available in Bulletin 620.
158b *Eastern Industries, Inc.

Mixers, Turbine.....in a range of ¼ to 40 H.P. solve many special mixing problems. Additional information can be found in Bulletin 1210. Send for your copy.
158d *Eastern Industries, Inc.

Mixers, Top Entering.....designed for heavy-duty applications requiring agitators from ¼ to 10 H.P. are discussed in Bulletin 620 which is offered.
158c *Eastern Industries, Inc.

Mixing.....Ko-Kneaders mix a wide variety of products such as plastics, carbon electrodes, food specialties, floor tile, solid rock propellant fuel & many others. Manual K-57.
154 *Baker Perkins Inc.

Mulling.....The 12-page handbook on mulling explains controlled dispersion & gives details on 9 Mix-Muller models (¾ to 60 cu. ft. batch capacity).
81 *National Engineering Co.

Pilot Plant Filters.....Bulletins and technical advice on the seven Pilot Plant Filters offered by FEinc. More information available on request.
161 *American Machine & Metals, Inc.

Process Equipment.....The Synchromatic action is positive & controllable & unaffected by variations in screen loadings. Plain or stainless steel construction.
14-15b *The De Laval Separator Co.

Process Equipment.....12-page bulletin discusses applications and performance characteristics of pumps, pneumatic conveyors, compressors, coolers, pre-heaters etc.
170A Fuller Co.

Process Equipment.....The new solids-processor performs up to 10 solids processing operations. All equipment is described in new process catalog No. 16-P.
36-37 *Patterson Kelley

Process Equipment.....Bul. No. 27 covers Extraction Columns, Mist Extractors, Entrainment Separators, Separator Vessels. Includes illustrations & Engineering Data.
170B York Process Equip. Corp.

Processing Vessels.....Welded aluminum tanks, pressure vessels and processing equipment for the chemical and processing industries. Booklet "Tank Talks" offered.
BL171 *R. D. Cole Mfg. Co.

Rotary Airlock Feeders.....Complete information on these feeders for dust control and pneumatic conveying is contained in Bulletin P 58.
B144 *Prater Pulverizer Co.

Scrubber, Gas.....A copy of the brochure giving complete data on Chemico Venturi gas scrubbers is available. Also technical assistance on a specific problem.
12 *Chemical Construction Corp.

* From advertisement, this issue.

LITERATURE . . .

Separator.....Application possibilities for the new PX self-opening separator in the processing of foods, fats, oils & chemicals. Leaflet is available.
14-15a *The De Laval Separator Co.

Pumps, Fans, Compressors

Blowers & Pumps.....12-page bulletin describes & illustrates the California Series of Rotary Positive Blowers; & the Series XB Gas Pump. Bul. S59-H.
171A Sutorbilt Corp.

Compressor.....New single-stage compressor bulletin features six-step "do-it-yourself" performance calculation method that permits selection of proper compressor.
171B Elliott Co.

Compressors, Centrifugal.....A complete line, consisting of single-stage, multistage, & axial flow machines, with integrated motor or turbine drives. 48 frame sizes.
31 *Elliott Co.

Compressors High Pressure.....for every purpose: single stage to six stages, from 0 to 42,000 psi pressures, for a full range of gases and air. Catalog 1960 available.
145 *Norwalk Company, Inc.

Fans.....New design duct fan by De Bothezat has a removable cone design. Descriptive literature on this new type is now available on request.
164 *American Machine & Metals, Inc.

Pump Motors.....Brochure contains collection of technical articles and is illustrated with charts, diagrams, graphs, tables and cutaways dealing with subjects covered.
171C U. S. Electrical Motors Inc.

Pumping.....20-page manual "Useful Pumping and Hydraulic Engineering Data" contains many useful charts and problem solving formulae plus many reference items.
171D Peerless Pump

Pump Pneumatic.....Diagrams, illustrations and charts shown in 4-page bulletin explain operation of pump particularly effective with problem materials.
171E Yeomans Brothers Co.

Pumps.....Durcopumps are available, standard or self-priming, with heads to 345 ft. and capacities to 3500 gpm. Bulletin P-4-100 for additional information.
131 *The Duriron Co., Inc.

Pumps.....New 6-page Bul. 101 includes cross-section drawings of the standard short coupled vertical turbine pump & the canned type vertical turbine pump.
171F Layne & Bowler, Inc.

Pumps.....Moyno pumps are available in nine sizes with capacities ranging from minimum metering flow to 500 gpm and pressures from zero to 1000 psi. Bul. 30 CE.
41 *Robbins & Myers, Inc.

Pumps.....Bul. V-837 describes the vertical pump for pumping molten chemicals and the horizontal pump that handles black liquor, caustic, etc., in evaporator service.
138 *Taber Pump Co.

* From advertisement, this issue.

LITERATURE . . .

Pumps.....Single stage double suction centrifugal pumps type DMB and DB are covered in Bulletin 251. Includes diagram, rating table and material specifications.
172A Warren Pumps, Inc.

Pumps.....HN pumps are built for flexibility & interchangeability. They handle temperatures to 850 F and pressures to 600 F. Data on request.
17-25a *Worthington Corp.

Pumps.....LN general purpose pumps use a casing design that gives hydraulic balance at any capacity. This design is called "Double Volute". Data.
17-25b *Worthington Corp.

Pumps.....Type MC is the Mixflo pump proven for irrigation, drainage, waste disposal, condenser circulating and low-head water supply. Sizes 10" to 84". Details.
17-25c *Worthington Corp.

Pumps.....The UNB & UNQ pumps design features the elastic seal ring that prolongs casing life by eliminating interstage leakage. Application & performance data.
17-25d *Worthington Corp.

Pumps.....The Standard End Suction Centrifugal line offers ratings in a range up to 2700 GPM and 230 ft. head. Additional information on request.
17-25f *Worthington Corp.

Pumps, Acid.....in a variety of metal alloys, as well as plastic, to cover a wide range of corrosive applications. 1" to 8" discharge sizes with 10 to 300 GPM.
189 *A. R. Wilfley & Sons, Inc.

Pumps, Elbow.....The KB elbow pump is designed with top suction to reduce installation cost. Supplied in Type 300 stainless steels & super stainless. Data.
17-25e *Worthington Corp.

Pumps Liquid.....6-page bulletin includes cross-section drawings of standard short coupled vertical turbine pump and the canned type vertical turbine pump.
172B Layne & Bowler Inc.

Pumps Sealless.....Pamphlet gives specifications, performance curves and dimensions on canned pumps recommended for handling volatile, toxic or inflammable liquids.
172C Goulds Pumps, Inc.

Services & Miscellaneous

Audio-Visual Programming.....Brochure explains technique designed to solve production problems in the manufacturing of complex products and systems.
172D Applied Communication Systems

Construction.....Units in a wide range of capacities from 25 tons to as high as 350 tons per day for your hydrogen recovery, purification or liquefaction problems.
185 *American Air Liquide

Engineers Handbook.....Vest-pocket book includes valuable information on Mathematics, Building, Mechanics, Heating, Hydraulics, Pipes, Surveying, Chemistry, etc.
172E Ottenheimer Publishers, Inc.

* From advertisement, this issue.

Fabrication.....Bulletins HE and CI contain information on materials and designs . . . all working, welding and testing operations. Quality control on all fabricating.
13 *Downingtown Iron Works, Inc.

Fume Hoods.....A 52-page illustrated catalog "Guided Airflow Fume Hoods" describes new principles of air removal engineering pertaining to Fume Hoods.
173A *Metalab Equipment Co.

Hydraulic Products.....Complete line of hydraulic products for the industrial, marine and ordnance fields is presented in 74-page catalog that includes circuit diagrams.
173B Vickers Inc.

Literature List.....A 20-page list of references spanning the years 1930-1960, giving authors and publications for papers on X-ray analysis is available.
173C Philips Electronic Instruments

Maintenance Painting.....24-page guide discusses different uses for various types of primers and finish coats and shows samples of the colors available.
173D The Sherwin-Williams Co.

Process.....Illustrated brochure describes the Carlile Processes. Includes flow diagrams of phosphoric Acid Plant and Ammonium Phosphate Plant. Bul. No. 160.
173E J. C. Carlile Corp.

Refining.....A very informative 16-page brochure describes a new $30 million copper refinery which has an annual capacity of 198,000 tons of 99.9+ per cent pure copper.
173F M. W. Kellogg Co.

Respiratory Equipment.....New bulletin shows full line of canister-type masks and a canister selector table for the 62 most common industrial gas and vapor hazards.
173G Willson Products Div.

Safety Tools.....4-page brochure describes line of non-sparking, non-corrosive tools that are desirable where sparks might cause fires or explosions.
173H Ampco Metal, Inc.

Space Testing.....Booklet describes space oriented test and research facilities for fundamental and environmental testing of components and systems.
173I Aerotest Laboratories Inc.

Technical Furniture.....This new 142-page catalog covers a complete line of metal laboratory furniture, fume hoods, plumbing and electrical fixtures.
173J Kewaunee Tech. Furn. Co.

Technical Reports.....New series of engineering bulletins to treat Optics & Electronics. Report No. 1 entitled, "Emissivity Enhancement of Solar Cells for Temp. Control".
173K Bausch & Lomb Inc.

Water Conditioning.....This data sheet discusses how the determination of steam sodium content has revealed the causes of turbine and superheater deposits.
173L Betz Laboratories, Inc.

Wire Cloth Calculator.....Pocket-size "slide rule" provides quick means for determining flow rate, pressure drop, particle retention, wire diameter etc. for wire cloth users.
173M Multi-Metal Wire Cloth Co.

* From advertisement, this issue.

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POSITIONS VACANT

Operating Manager Wanted: Evaporated salt plant in south wants experienced superintendent to manage operation. Work record required to show ability to manage plant and handle people. Opportunity for right person. P-5216, Chemical Engineering.

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4' Telsmith TY Gyratory Crusher
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72" x 28' Madsen Rotary Dryer
F55 Syntron Grizzley Feeder
10—1½ & 2 Yd. V-Shape Dump Cars
2—5' x 8' KVS Air Swept Ball Tube Mills
Ball Mills: No. 56, 6' x 4', 6' x 9' & 7' x 22'
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Rotary Dryers: 3'x30', 5'x30', 6'x70' & 8'x80'
Rotary Kilns: 36" x 30', 6' x 70' & 9' x 160'
Reto Louvre #207-10 Types 316 SS, Link Belt
Louisville Monel Steam Tube Dryer, 54" x 35'
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4' x 10' Tyler-Hummer Electric Vibrating Screen
2'x6' & 3'x12' Seco Single Deck Vibrating Screen
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Aluminum Condenser 350 sq ft.
Aluminum Evaporator Calandria type, never used. 1300 sq feet tube area.
Continuous Stripping column 2 x 13 Steel.
Hydraulic Pumps & Meters.
Dryers Vacuum Shelf.

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MIXERS: Baker Perkins size 17, 200 gal., double arm 200 gal.; Hottman 8¾ cu. ft.; Hobart 80 quart; J. H. Day 130 cu. ft.
TANKS: 1,000, 2,300, 3,000 and 6,500 gal. S/S lined.
MILLS: Fitzpatrick Mod D 6 S/S; Mikro 2TH; Prater 009; Rietz Disintegrator Model 18 RD P; Cage mill.
HEAT EXCHANGERS: Foster Wheeler from 79 to 520 sq. ft. heating surface, type 316 S/S tubes & crown sheets.
CENTRIFUGE: Tolhurst 20" type 316 S/S Hydraulic drive.

AARON EQUIPMENT CO
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Gladstone 1-1500

CIRCLE D ON READER SERVICE CARD

Check this issue's listings—most complete in the field—for items you need now

Equipment Wanted
DRYER—Continuous Apron Conveyor type. Total drying area approx. 250 sq. ft. Apron construction, stainless steel.
HAMMER MILL—#3 Mikro or equivalent.
MIXER—Double arm, blade tilting type. 300 gal. working capacity. Steam jacketed. 40 H.P. Stainless steel construction.
ROTARY AIR LOCKS—8"—12".
BALL MILL—6' x 10' Jacketed. Chrome Manganese Steel.
STAINLESS REACTOR—Min. size 6'6" x 8'. Must be built for 100 PSI pressure.
3 STAINLESS STEEL CONDENSORS—300 to 400 sq. ft. of tube surface.
Please include price information with full particulars in the first letter. Indicate if you own the equipment and where it is available for inspection.

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Class. Adv. Div., P.O. Box 12, N.Y. 36, N.Y.

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54" x 72"—150,000 Cu. Inch
Almost New
GLOBE TRADING COMPANY
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CIRCLE F ON READER SERVICE CARD

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Abbe 5' x 6' J'ktd. Ball Mill, chrome mang. steel
2 Oliver Rotary Vac. Filters, 3' x 2', 63" x 8'
3 Bird Filters, 18" x 28", 4' x 1' & 24"
Ribbon Blenders, Steel & SS, all sizes, New & Used
Gen. American 42" x 120" Twin Drum Dryer
Gruendler "BB" Hammermill. Whirlwaster
Day 2/4 gearless 80 gal. Pony Mixer, 10 hp.
Pfaudler 1500 gal. glass enclosed top Tank
Colton # 5½ Preformer, max. size 3" x 2⅛" tablet

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AIR COMPRESSOR
6700 CFM Sullivan 2 stage Model HE522 30½" & 18½" x 20" direct connected to 1250 H.P., G.E. Syn. Motor—200 RPM 3/60/4160 V.

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LINK-BELT ROTO-LOUVER DRYER
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Sharples C-20 and C-27 Super-D-Hydrator, 316 S.S.
Bird 18"x28", Solid Bowl, Continuous, 304 S.S.
Bird 32"x50", Solid Bowl, Continuous, 316 S.S.
Sharples PY14, PN14 Super-D-Canters 316 S.S.
Tolhurst 26" susp. Rubber Imperforate Basket.
Fletcher 48" Suspended 316 S.S. Perforated Basket.
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Pfaudler 200 gal. Glass Lined Jacketed Kettles.
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1400 gal. Blaw-Knox, steel, jacketed, agitated Reactor.
700 sq. ft. Buflovak 304 SS Forced Circulation Evaporator.
550 sq. ft. Buflovak monel single effect Evaporator
7300 gal. 316 S.S. Vert. Storage Tank, 7'x25', 50 psi.
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7,500, 6,000 and 2,000 gal. Rubber Lined Tanks.
4000 gal. Haveg Vert. Tank 8'x12'.
7500 gal. Rubber Lined Tanks 10'x13'.
2,000 gal. horz. 304 S.S. Tank 5'x12'.
1500 gal. Stainless Pressure Tank, 5'x10', 90#.
12,000 gal. horiz. steel Pressure Tank, 7'6"x36', 200 psi.
Stainless Heat Exchangers; 1220, 786, 536, 370, 315, 250 sq. ft.
Falls Industries 100 sq. ft. Karbate Condenser.
24" dia. x 35', 304 S.S. Bubble Cap Column.

FILTERS

#5 Sweetland Filter 304 S.S. 120 sq. ft.
Oliver 6' dia. Horizontal Filter, 316 S.S.
Oliver 5' x 6' Steel Rotary Vacuum Precoat Filter.
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18"x12" 316 S.S. Rotary Vacuum Filter with pumps and piping.
Oliver 3' x 2' 347 S.S. Rotary Vacuum Filter.
Feinc 5'x6' Stainless Steel Rotary Vacuum Filter.
#10 Sweetland Filters, 27 leaves, 4" centers, 250 sq. ft.

DRYERS

Buflovak Vacuum Shelf with 20—60"x80" shelves.
4' dia. 304 SS Spray Dryer.
Devine Vacuum Shelf with 19—59"x78" shelves.
Devine Vacuum Shelf with 10—40"x43" shelves.
Buflovak 42"x120", atmospheric double drum Dryers, complete.
Devine 4'x9', single drum, atmospheric.
Buflovak 3'x10' Rotary Vacuum Dryer.
Baker Perkins 5'6"x6" Rotary Vacuum Dryer.
Buflovak 5' x 30', 3' x 7'6" Rotary Vacuum Dryers 316 S.S.
Louisville Rotary Steam Tube 6x25', 6'x50'.
Louisville 8'x50' Stainless Steel lined Rotary Dryers.
Rotary Dryers 34"x30', 4'x40', 6'x50',6'x60', 7'x80', 8'x87'.
Traylor 30"x18' Stainless Steel Rotary Dryer.
Link Belt, 7'5"x25', 6'4"x24", S.S. Louvre Dryers.
Atmos. Tray Dryers, 16 shelves, 40"x24".
P&S 10' wide Apron Conveyor Dryer 48' long.

MIXERS

Farrell-Birmingham "Midget" Banbury Mixer.
Day Imperial 150 gal. jktd. double arm.
Baker Perkins 100 gal. jktd., double arm, 30 HP.
Baker Perkins #16TRM, 150 gal. jktd., Vac. 60 HP.
Baker Perkins 50 gal. jacketed, double arm.
Baker Perkins 10 gal. jktd. 304 SS Double arm.
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Steel jacketed Powder Mixers, 225 and 350 cu. ft.
Patterson 6' dia. Conical Blender 15 HP.
3' dia. Simpson Intensive Mixer.

MISCELLANEOUS

Farrel Birmingham, 8" x 16", 2 Roll Chrome Plated Mill.
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Raymond 10" vert. mill 10 HP.
Bantam Mikro Pulverizers, S.S.
No. 1 Ball & Jewell Rotary Cutter.
#18 Cumberland Rotary Cutter.
Swenson Walker Continuous Crystallizers, 24"x 30 sections.
5 Day Roball Sifters 40"x120" single and double deck.
#22 Rotex Sifter 40"x56" double deck.
#91 Day Roball Sifter 40"x120" single deck.
Nash H6 Vacuum Pumps.
Chlorimet Durimet and Duriron Centrifugal Pumps 1½" to 6".

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Complete with motors and conveyors.

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Downington Iron Works 5000 gal. vert. jcktd. agit. Mixing Tank w/Mtrs.

Patterson 4' x 5' jcktd. Ball Mill with 10 HP Ex proof Motor.

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For immediate quote, wire or phone collect—GA 1-1380

ME MACHINERY AND EQUIPMENT COMPANY
123 Townsend St. - San Francisco 7, California

CIRCLE N ON READER SERVICE CARD

Buffalo 32"x90" Double Drum Dryer.
Day Hy—R Speed Mill 20 HP.xP.
Centrifugals: 12", 30", 40" & 48".
Centrifuges: Sharples #5 & #6 Stainless.
Dryers: Hersey 5'x26' Rotary, 316 Stainless
Buffalo Vac. Drum Dryer 24"x20".
Despatch Ovens Elec. Heated.
3—Devine & Stokes Vac. Shelf Dryers
Hope Stainless Can Filler pts. to gals.
Filters: #2 Sweetland 12 Stainless Leaves.
Filter Presses: 6" to 36" Iron & Wood.
Kettles: S.S. Jack 20 to 500 gals.
Dopp 350 gal. cast iron Jack. Vacuum.
Devine Impreg. Units 30" & 36" dia.
Mills: Raymond #00, 30 HP. & #0000.
Mikro Pulverizers #4, 2, 1, & Bantam.
Hammer Mills & Pulverizers 3 to 50 HP.
Taylor-Stiles 7½ HP. Cutter.
Rotary Cutters 1½ to 5 HP. & up.
Spr. Waldron Stainless spike crusher.
Pebble, Jar & Ball Mills, Lab. to 6' x 8'.
3 Roll, 9" x 32", 12" x 30", 16" x 40".
Lehman 4 Roll W.C. 12' x 36" Steel.
Colloid Mills 1½ H.P. & up.
Mixers: Baker Perkins jack. 100 gals.
B.P. 15 HP. Masticator Mixer.
Day Imperial 75 & 150 gals.
Change Can Mixers 8, 15, 40, 150 gal.
Sprout-Wald. 10,000# horiz. Spiral Mixer
Day Jumbo 700 gal. horiz. mixer.
Blystone 3000# horiz. spiral mixer.
Day 1000# Ribbon Mixer & other sizes.
Lancaster 6' dia. 25 HP. & # 1, 3 HP.
Pumps: Stokes etc. Vac. 10 to 500 CFM.
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Partial Listings. Write for Bulletins

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GArfield 6-2221

CIRCLE S ON READER SERVICE CARD

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2,000,000 ft. 2"	3.68#	to the foot
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500,000 ft. 6"	19.80#	
200,000 ft. 8⅝"	28#	
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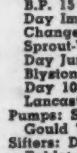
COLUMBUS 19, OHIO

CIRCLE P ON READER SERVICE CARD

STAINLESS STEEL TANKS



24" x 45", 10 gauge, 400 PSI, type 304, ¼" pipe thread each end. *NEW*, $300 value, $99.50. Size 8½" x 18", 16 gauge, $14.50. Case of 8, $14.25. F.O.B. Baton Rouge, Louisiana.

Illinois Mfg. & Supply Co.
1829 S. State, Chicago 16, Illinois

CIRCLE Q ON READER SERVICE CARD

FOR SALE

BAKER PERKINS MIXER

"Unidor" Type-Size 14 DUM
Working Capacity—5 Cu. Ft.

GLOBE TRADING COMPANY
1815 Franklin St. Detroit 7, Mich.

CIRCLE R ON READER SERVICE CARD

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Classified Advertising Division
Chemical Engineering
P.O. BOX 12, N.Y. 36, N.Y.

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CHEMICAL ENGINEERING
P. O. Box 12, N. Y. 36, N. Y.

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TITLE .....
COMPANY .....
STREET .....
CITY .....ZONE.....
STATE.....10/3/60

AGITATOR—S/S w/10 HP xpl. proof 2 spd motor, 3" shaft x 6' long w/propeller—1 HP Lightnin' 1150 RPM

SCREENS—12" x 72" S/S Ajax—20 x 84, 20 x 96 Rotex—3 x 5, 3 x 10 Tyler Hummer

FEEDERS—S/S Vibrating 4½ x 24, 24 x 72 Syntron—Hardinge B Constant Weight

MILLS PULVERIZING—3 HP Sturtevant 00—10 HP Mikro 2 TH—30 HP Raymond—50 HP Mikro 3 TH w/Mikro Collector (unused)—100 HP Jeffrey 36 x 42—250 HP non-clog—450 HP Penna. SXT 14.

DRYERS, ROTARY—24" x 22', 3' x 24', 4' x 40', 5' x 50', 6' x 30', 7' x 58' all w/motor drives

DRYER, VACUUM SHELF—w/13 shelves 59" x 78", total area 356 sq. ft.

BRIQUETTING MACHINE—Komarek Greaves, 11/16 x 4-5/16 x ¼" dies w/feeder, motors, etc.

LAWLER COMPANY

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LOEB OFFERINGS

Autoclave: 50 gal. Struthers Wells, st. st.
Centrifugal: Tolhurst 20" st. steel (New).
Centrifugal: AT&M 60" st. st. perf.
Dewaterers: Davenport 3A, bronze hd. 3 hp.
Disintegrator: Rietz RD18P, 75 hp.
Dryers: Devine 2 x 4' vac. drum, st. steel.
Dryers: Bowen lab. spray, st. steel.
Dryer: American atmospheric 24 x 48".
Dryer: Davis #7 13-shelf 60" x 7'.
Evaporator: Buflovak st. st., 94 sq. ft.
Filter: Sweetland #5 st. st. lined.
Filter: Oliver precoat 12 x 2" st. steel.
Filter: Eimco st. st. drum 16" x 12".
Filter Press: Shriver 24" St. steel.
Separator: Sweco model G-ID 3 st. steel.
Homogenizers-Disperser: Tri-Homo #10, #4.
Homogenizers: 25, 50, 125, 200, 1200 GPH.
Kettles: st. steel with and without ag.
Dopp 150 gal. dbl. act. agitator.
Mills: Mikro Atomizer 5MA, st. steel.
Day 3-roll high speed 14 x 30".
Mixers: Dbl. and sgl. arms sigma blade.
Dry Powder, various sizes.
Pumps: Rotary, gear, centrif., vacuum.
Screen: Rotex model 41 st. steel.
Tablet Press: Stokes DD2, 23 station.
Vacuum Pans, 42" and 72" stain. steel.

LOEB EQUIPMENT SUPPLY CO.

CIRCLE U ON READER SERVICE CARD

COMPRESSORS

No better values at any price

74 CFM 1500 PSI 6¼-3⅝-1⅝x7 CP, TCB3
104 CFM 2500 PSI 6⅝-4½-1-11/16x9 IR-ES3
110 CFM 3000 PSI Ing. GC 50BW
138 CFM 100 PSI 7x7, Ing. ES, CP & Joy
151 CFM 3000 PSI 13⅜x12 Norwalk TRS-4T
288 CFM 100 PSI 9x9 Ing. Worth, CP
311 CFM 1500 PSI 10½-7¼-3⅝x13 IR-ES3
351 CFM 350 PSI 11-5x11 CP TCB-2
364 CFM 100 PSI 10x9 Joy WG 9
465 CFM 100 PSI 12x11-IR-ES CP.T. Worth HB
660 CFM 125 PSI 11¼-7x7 Joy Wn 102
676 CFM 125 PSI 15-9¾x12 IR XCB
686 CFM 100 PSI 14x13 Ing. ES-Chic. P.T.
877 CFM 125 PSI 17-10½x14 IR, XRB
1050 CFM 60 PSI 13-13x12 IR-XRE
1665 CFM (actual) 100 PSI C300-300H Fuller
1721 CFM 110 PSI 23-14x16 Ing. PRE2

AMERICAN AIR COMPRESSOR CORP.

Chem. Road, North Bergen, N.J. UNion 5-1397

CIRCLE V ON READER SERVICE CARD

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ROTEX SCREEN

Model 421 Single Deck. 60" x 84" Screen. 2 HP Motor.

EXCELLENT CONDITION

ME MACHINERY AND EQUIPMENT CO.

123 Townsend St., San Francisco 7, Calif.

CIRCLE W ON READER SERVICE CARD

CHEMICAL EQUIPMENT DIVISION

Proudly Presents

2 More CHEMICAL PLANT LIQUIDATIONS

FEATURING QUALITY EQUIPMENT

ATTRACTIVE PRICES - IMMEDIATE REMOVAL

Everett, Mass.

Sharples C-27 Centrifuge 316 SS
Eimco 4'x2' Rotary Vac. Filter 316SS
SS Centrifix Eliminator 42"x12'6"
Sparkler 33-D-12 Filter, 316 SS
Sparkler 18-D-8 Filter, 316 SS
B&P Ter Meer S32 Centrifuge 316 SS
Swenson 24"x20' jkt. SS Crystallizers
Stainless Condensers 50 to 3000 sq.ft.
Absorber Column 18'x66' Stainless
Swenson Evaporator 425 sq.ft. Stainless
Bubblecap Columns 7'x25'—8 trays; 5'x88'—35 trays; 3'x88'—35 trays
Baker Perkins 18DIM 300 gal. Mixer
100 Stainless Steel Tanks with and without agitators 500 to 21000 gal.
100 Steel Tanks 1000 to 350,000 gal.
Lummus Stills 4 Million BTU
11'6"x34' Crude Still, welded
Petro-Chem Furnaces, 9; 7; & 2 MM/BTU
Penna. SX13 Hammermills, 400 HP
Heil Patterson Crushers, 100 HP
Koppers 36"x42" —2 Roll Crushers
10,000ft Trough Conveyor 30"; 36"; 42"
Stainless Centrif. Pumps 2"x2" to 6"x5"
Sturtevant 6"x4" Lab. Roll Crusher
Sturtevant 6"x5" Lab. Jaw Crusher
Screens 4'x6'6"—1 Deck; 5'x8'6"—3 Deck
Patterson Uni-Power Drives 1 to 20 HP
G.E. 750 KW Motor Generator Sets
Centrif. Blowers 23M; 29M; 50M, CFM
INSTRUMENTS — COMPRESSORS — CRANES — STEEL AND STAINLESS VALVES, TUBING & PIPE — BUCKET ELEVATORS — TRANSFORMERS — MOTORS — REDUCERS — VIBRATORS —TROMMEL SCREENS—WEIGHTOMETERS—COKE OVENS—UNLOADING TOWERS—BARBER GREENE PORTABLE LOADERS — CAR SHAKERS — SKIP HOISTS—STEEL BINS—STRUCTURAL STEEL etc., etc.

Jersey City, N. J.

A. O. Smith 3'x78' Inconel Clad Tower. inconel plates, 750 PSI
Foster Wheeler Dowtherm Boiler. 2.2 MM/BTU/HR. 150 PSI, 650°F.
Kemp Inert Gas Producer. 1000 SCFH
Stainless Steel Pressure Vessels 150 to 2500 gal.; 75 to 125 PSI
Stainless Steel Tanks 200 to 750 gal.
Steel Pressure Vessels 300 to 4000 gal. 40 to 115 PSI.
Steel Tanks, 5000 to 12000 gal.
2'x20' Stainless Deaerators
Stainless Steel Heat Exchangers—68, 136, 235, 350, 650, 1000, 2300 sq. ft.
Brown Fintube Exchangers, size 182020
Stainless Steel Pumps 20 to 325 GPM
Union Triplex Pumps 18 GPM @ 2000 PSI Stainless Steel
I.R. 5"x4" Type ER1, Compressor, 5 HP
Westinghouse 4½"x5" Compressor 15 HP
Stainless Steel Valves, Tubing & Pipe

INSTRUMENTS—TRANSFORMERS
MOTORS—STRUCTURAL STEEL

FROM STOCK

#5057 Raymond 5 Roll Hi-Side Mill
#3036 Raymond 3 Roll Hi-Side Mill
Rotary Kilns 8'x60'; 8'x115'; 4'x30'
Roto Louvre Dryers 1106-36; 705-25; STAINLESS 604-24; 310-16; 207-10
Traylor 8'x11' Ball Mill, Steel Lined
Tolhurst 40" SS Centerslung Centrif.
Buflovak Shell Dryer 18-42"x42" shelves
Shriver 30"x30" Filters 36 P&F 1" cake
Sweetland #7 & #12 Filters
6'x29' Column 347 SS 20 tray
Screens 60"x84"; 40"x84"; 30"x96" SS

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HEAT & POWER CO., Inc.

60 East 42nd Street, New York 17, N. Y. Murray Hill 7-5280

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CIRCLE X ON READER SERVICE CARD

ANOTHER PERRY LIQUIDATION

$8,000,000 ALCOHOL PLANT

OMAHA, NEBRASKA

MAJOR ITEMS

PRESSURE LEAF FILTERS

1—Sparkler #33-S-17, T304 SS, 91 sq. ft., w/scavenger

1—Sparkler #33-S-7, T304 SS, 37.8 sq. ft., w/scavenger

2—Sweetland #12, (24)—36" dia. leaves, 336 sq. ft.

6—Shriver 48" Cast Iron P.&F. filter presses, 50, 48, & 40 chambers, hydraulic closure

1—Sperry 30" C.I. P.&F. filter press, 30 chambers.

EVAPORATORS—HEAT EXCHANGERS—STILLS

2—Quadruple-effect evaporators, calandria type, 4050 sq. ft., cast iron bodies & copper tubes. With 1230 sq. ft. horizontal copper preheaters, & 2450 sq. ft. finishing pans. Total 19,900 sq. ft. each evaporator.

7—Ansonia 691 sq. ft. horiz. Bbl. pipe coolers, copper inner tubes, steel outer tubes.

8—American 654 sq. ft. spiral steel heat exchangers.

18—Tubular heat exchangers, copper tubes, 1500, 1350, 1130, 637, 380, 290, 184, 176, 156 sq. ft.

2—Acme 96" dia. x 44' high copper beer-still columns, (20) perforated & (4) bubble cap trays.

5—Leader 96" dia. steel rectifying columns, 44' & 51' high, bubble cap trays.

DRYERS

12—Buflovak 42" x 120" double drum, ASME 160#

2—Bonnet 7' x 60' rotary hot-air, ⅝" shell

2—Bonnet 6' x 50' rotary hot-air, 5/16" shell

2—Davenport 6' x 30' rotary steam tube dryers

PRESSES

6—Davenport #2A dewatering presses

3—Davenport #1A dewatering presses

2—French Oil Screw Extraction presses, 60 HP.

PULVERIZERS—GRINDERS

10—Forster hammermills, #8, 6, 75 & 100 HP.

8—Nordyke & Marmon roller mills, 2-rolls; 10 x 36, 10 x 42, 30 & 20 HP.

1—Stedman reversible hammermill, dbl. V-belt drive

4—Western "Bearcat" hammermills

2—Allis-Chalmers Interplane grinders.

1—Prater "blue-streak" hammermill, 30 HP.

SCALES

4—Wallace & Tiernan auto. bulk handling scales, elec. operated, capacity to 2000#/min.

4—Fairbanks tank scales, to 75,000# capacity

20—Scales, dial, beam, etc., all sizes. Also track scales, truck scales, etc.

MISCELLANEOUS

2—Horiz. steel precookers, 6' 6" dia. x 25' long.

250—Steel pumps, 1" to 10", 1 HP to 150 HP.

200—Steel tanks & bins, all sizes & types.

100—Steel & stainless steel screw conveyors, to 161' long.

15—300 amp. welders, elec. & gasoline drive.

4—Lightnin' #SAG-2500 S.E. agit., 18" dia. prop., 25 HP TEFC motor.

9—Davenport 5' x 25' inclined "slope" dewatering screens, copper paddles, gearhead drive.

2—DeLaval 48" multi-matic separators, st. st.

8—Allis-Chalmers Degerminators.

6000 HP—TEFC motors, 3/60/220-440/, up to 150 HP.

20—Steam turbine, up to 150 HP.

REPRESENTATIVE ON PREMISES AT OMAHA, NEBRASKA

Hundreds of Items Too Numerous To List!

Send for Circulars & Detailed Information

PERRY EQUIPMENT CORPORATION

1413-21 N. SIXTH ST. PHILADELPHIA 22, PA.

Phone POplar 3-3505

CIRCLE Y ON READER SERVICE CARD

AMERICA'S LARGEST STOCK

ROTARY DRYERS & KILNS

3—10′ x 78′ National rot. dryers, ¾″ shell
1—10′ x 11′ x 175′ Vulcan Kiln, 13/16″ shell, 2-tire
2—8′-8″ x 70′ Hardinge #XA-18 dryers, ⅝″ welded
1—8′ x 60′ Davenport rot. dryers, $\frac{7}{16}$″ welded
1—8′ x 60′ Consol.-Western Kiln, ½″ welded
3—8′ x 40′ Stearns-Roger dryers, ½″ shell
1—7′-6″ x 62′ rotary kiln, ½″ welded
1—7′ x 70′ Louisville rot. cooler, ½″ welded
2—7′ x 60′ Bonnet rot. dryers, ⅝″ shell
1—7′ x 50′ Allis-Chalmers dryer, ⅝″ shell
2—6′ x 52′ Bonnet rot. dryers, $\frac{5}{16}$″ shell
1—6′ x 50′ Louisville rot. steam-tube dryer
2—6′ x 30′ Davenport rot. steam-tube dryers
1—6′ x 25′ Louisville rot. steam-tube dryer
1—6′-4″ x 18′ Link-Belt #604-18 Roto-Louvre
1—5′-6″ x 30′ rotary dryer, ⅜″ shell
2—4′-9″ x 32′ rotary dryers, ⅜″ shell
1—4′-6″ x 40′ Ruggles-Coles rot. dryer
1—4′ x 12′ rotary stainless steel dryer
1—4′ x 30′ Hardinge rot. steam-tube dryer
1—3′-10″ x 20′ Link-Belt #310-20 Roto-Louvre
1—3′ x 23′ Standard rot. dryer, ¼″ welded
1—3′ x 15′ Bartlett dryer, Everdur shell
1—3′ x 10′ rotary stainless steel dryer
2—2′ x 9′ rotary perf. shell dryers
1—1′ x 8′ rotary stainless steel dryer

SEND FOR "DRYER" CIRCULAR #860A

RECENT STOCK PURCHASES

2—#3TH Mikro Pulverizers, stirrup hammers
1—Raymond 50″, 5-roller hi-side mill
1—J. H. Day #8, 150 gal. sigma blade Cinc. mixer
2—J. H. Day #5, 75 gal. sigma blade Cinc. mixers
1—Buflovak 110 sq. ft. Vacuum shelf dryer
1—Buflovak 98 sq. ft. Vacuum shelf dryer
1—Patterson 6′ x 10′ pebble mill, porcelain lined, jacketed.
1—Sturtevant #9 rotary blender, 150 cu. ft., int. lifters, UNUSED.
1—Baker-Perkins #15-UUMM, 100 gal. dispersion blade jacketed mixer, cored blades, 100 HP XP drive, compression cover.
2—Hardinge 7′ x 36″ conical pebble mills
1—Bird 32″ x 50″ T316 SS horiz. cent.
1—A.T.&M. 12″ dia. susp. cent., T304 SS, perf.
1—Tolhurst 48″ dia. sus. cent., T304 SS, perf.
22—Sharples #AS-16V super centrifugals, sludge disch. frame, Inconel, 3 HP.

CLOSING OUT!

CHEMICAL PLANT—ORANGE, TEXAS

TYPE 316 STAINLESS STEEL EQUIP.

1—Struthers-Wells T316 SS 3500 gal. jkt. reactor, agit.
1—Struthers-Wells T316 SS 630 sq. ft. calandria type single-effect evap., 2″ OD T316 SS tubes
2—Sharples #C-20 Super-D-Hydrators, T316 SS
1—Sharples #16-P Super-cent., T304 SS
1—Vulcan 110″ dia. T316 SS bubble-cap scrubber column, 13′ high, 10 trays
1—Vulcan 96″ dia. T316 SS bubble-cap column, 37′ high, 30 trays
1—Vulcan 72″ dia. copper bubble-cap column, 46′-10″ high, 40 trays—VACUUM
1—Vulcan 60″ dia. T316 SS bubble-cap scrubber column, 13′ high, 10 trays
3—Worthington 160 ton steam-jet vacuum refrigeration units, with baro. cond., etc.
2—Read 1800 cu. ft. T304 SS weigh hoppers, on scales, with shaker-conveyors, etc.
2—Bucket elevators, T304 SS, 5″ x 3¾″ T304 SS buckets on T304 SS chain: 60′, 41′ high c/c
2—18,000 gal. Aluminum tanks; 12′ dia. x 31′ OAH
2—American T316 SS blowers, 5600 cfm, 50 HP
2—Buffalo T316 SS blowers, 2330 cfm, 60 HP
1—1200 gal. horiz. steel still kettle, 5′ x 8′, ⅝″ shell & dished heads, 320 sq. ft. int. coil
2—1450 sq. ft. T316 SS heat exchangers, 1″ OD tubes
6—1400 sq. ft. T316 SS heat exchangers, 2″ OD tubes
5—800 sq. ft. T316 SS heat exchangers, ⅝″ OD tubes
1—800 sq. ft. T316 SS heat exchanger, 1″ OD tubes
1—730 sq. ft. T316 SS heat exchanger, 1″ OD tubes
19—T316 SS tubular heat exchangers: 510, 427, 410, 400, 390, 290, 277, 264, 250, 125, 54, 52, 50, 47 sq. ft.
1—Otis 5000# cap. elec. frt. elevator, 40′ lift

TYPE 316 STAINLESS STEEL TANKS

3—2750 gal. vert., 7′ x 8′, ¼″ shell & dished heads.
2—2300 gal. vert., 7′ x 8′, ¼″ shell, $\frac{5}{16}$″ dished top, ⅝″ flat bottom. Paddle agit., 60 sq. ft. U-tube coil.
4—2250 gal. vert., 7′ x 6′-3″, vert., dished heads, 3 HP paddle agit.
1—2100 gal. vert., 6′ x 9′-10″, open top, cone bottom.
1—1900 gal. vert., 6′ x 8′, ⅜″ shell & dished heads—VACUUM.
6—685 gal. vert., 3′ x 13′, open top, 120 sq. ft., int. coil.
15—100 gal. separator tanks, cone bottoms, 20# WP.
30—T316 SS tanks, 18 to 200 gal.

SEND FOR CIRCULAR #1259A

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"THE GELB LIQUIDATOR"

By Popular Demand . . . This GELB GIRL was selected to announce all GELB liquidations for 1960. If you have a plant or any equipment that you would like to handle with her . . . just give her a buzz . . . at MUrdock 6-4900.

LIQUIDATING

Ten Million Dollar Chemical Plant

NORTH JERSEY AREA

Type 316 Stainless Steel Equipment

7—Alloy Fabricators Type 316 SS pressure vessels, 4500 gal., complete with agitators and drives, 45 psi.

2—Alloy Fabricators Type 316 SS, 4500 gal., jacketed reactors, complete with agitators and drives.
2—Alloy Fabricators Type 316 SS, 1000 gal., jacketed kettles, ⅜" material throughout.
12—Whitlock Type 316 SS pressure vessels with coils, 270 gals.
3—Whitlock Type 347 SS pressure vessels with coils, 300 gals.
3—Type 316 SS mixing tanks, 6000 gal., complete with agitators and drives.
8—Acme Type 347 SS settling tanks with cone bottoms, 1000 gal.
1—2600 gals, Type 316 SS vertical vacuum receiver.

3—Vertical Type 316 SS activated carbon absorbers, 5'4" dia. x 16'.

1—Struthers Wells 75 gal. Type 316 SS 500 lb. pressure vessel ASME code National Board.
2—Project fabricators type 316 SS vacuum receivers, 160 gals.
2—Pfaudler 500 gal., glass lined jacketed kettles.
1—Pfaudler 20 gal., glass lined vacuum receiver.
1—Haveg, 500 gal., vacuum receiver.
2—Aluminum horiz. 5000 gal. storage tanks.
5—Pfaudler horiz. glass lined storage tanks, 5000 gals.
1—Pfaudler vertical glass lined storage tank, 5000 gals.

4—Rubber lined horiz. storage tanks, 5000 gals., working pressure 45 lbs.
16—Rubber lined vertical storage tanks, 4500 gals., working pressure 45 lbs.

2—Rubber lined vertical storage tanks 2500 gals, working pressure 45 lbs.

11—Patterson-Kelley type 316 SS condensers, 75, 84 and 235 sq. ft.
4—Type 316 SS packed columns, 18" x 11'7½", working pressure 45 psi
2—Shriver 18" x 18" SS plate and frame filter presses, 10 chambers.
5—Shriver 42" x 42" wood plate and frame filter presses, complete with hydraulic closing device, 30 chambers.

7—Buflovak Type 316 SS jacketed rotary vacuum dryers, 5'x30', complete with 25 H.P. explosion proof motors and drives

3—Type 316 SS Ter-Meer continuous type centrifuges 4' dia. bowls complete with motors.
3—Readco stainless steel horizontal blenders, 450 cu. ft. working capacity, complete with 75 HP motors
3—Mikro model 3 TH stainless steel pulverizer, complete with 40 HP explosion proof motors
1—Mikro SS bantam pulverizer, model CF, complete with ¾ HP explosion proof motor.
3—Gruendler SS, lab size, pulverizers.
3—Nash, Model TS-12, vacuum pumps, with motors.
1—Stokes Type 316 SS, jacketed, rotary vacuum dryer, 2' x 3'.
14—Copper jacketed mixing kettles, 3500 gal. each.
14—Copper jacketed rotary vacuum dryers, 8 x 10.
5—American type 316 SS blower model MD, size 27".
1—Fuller Type 316 SS, airveying system.
1—Aldrich Groff type 316 SS hydraulic triplex pumps, size 2¾" x 4" at 500 PSI.
1—Quimby type 316 SS twin screw pump with 10 hp variable speed drive.
100—Stainless steel centrifugal pumps, all makes and sizes.
2—Powell type 316 10" hydraulically operated flanged and gate valves.
2—Tyler type 38 tandem SS Hum—mer screens, size 42" x 9'8".
3—Williams type 316 SS hammer mills with 100 HP motors.
3—150 gals. type 316 SS jacketed kettles.
3—200 gals. type 316 SS jacketed kettles.
12—Type 316 SS cyclone separators, 5'2" x 10'8" overall.
500 Tons of type 316 stainless steel pipe, fittings, and valves, ranging from 2" to 6".
500 Tons of structural steel.
50—Stainless steel and aluminum hoppers, all sizes.

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what's your best estimate?

. . . a quiz for Chemical Executives who want to keep posted

QUESTION 1. According to a recent survey by the Manufacturing Chemists Assn., nearly 50% of its members are engaged in, or have an interest in, foreign operations. Can you guess what per cent of total capital outlay by U.S. chemical companies in 1959 was for plants and facilities overseas?

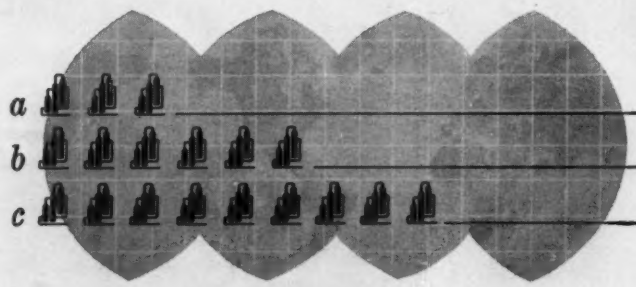
a $$$$$ ——— 5%

b $$$$$$$$$$ ——— 10%

c $$$$$$$$$$$$$$$ ——— 15%

d $$$$$$$$$$$$$$$$$$$$ ——— 20%

QUESTION 2. How many chemical and petrochemical plants has Lummus designed, engineered and/or constructed abroad since World War II?



ANSWERS: 1. *(c) is correct. MCA reports that an estimated 15% of the money spent by U.S. chemical companies in 1959 went for plants and facilities overseas.*

2. *The answer is (b). Lummus has designed, engineered and/or constructed 61 chemical and petrochemical plants in 11 foreign countries since 1945. Seven international members form the Lummus group of companies which circles the globe.*

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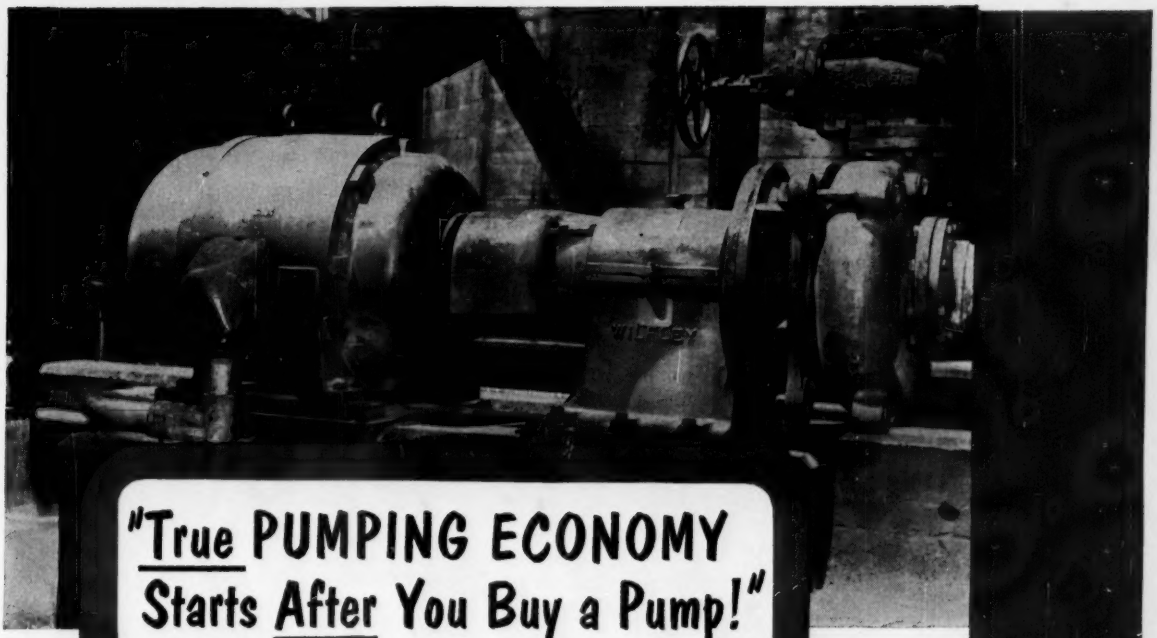

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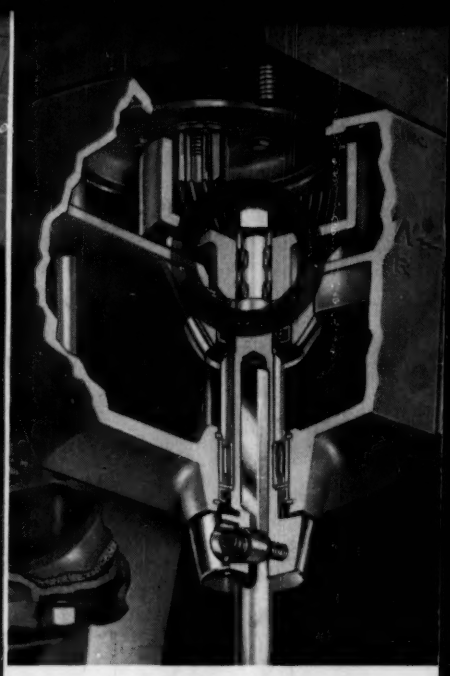

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